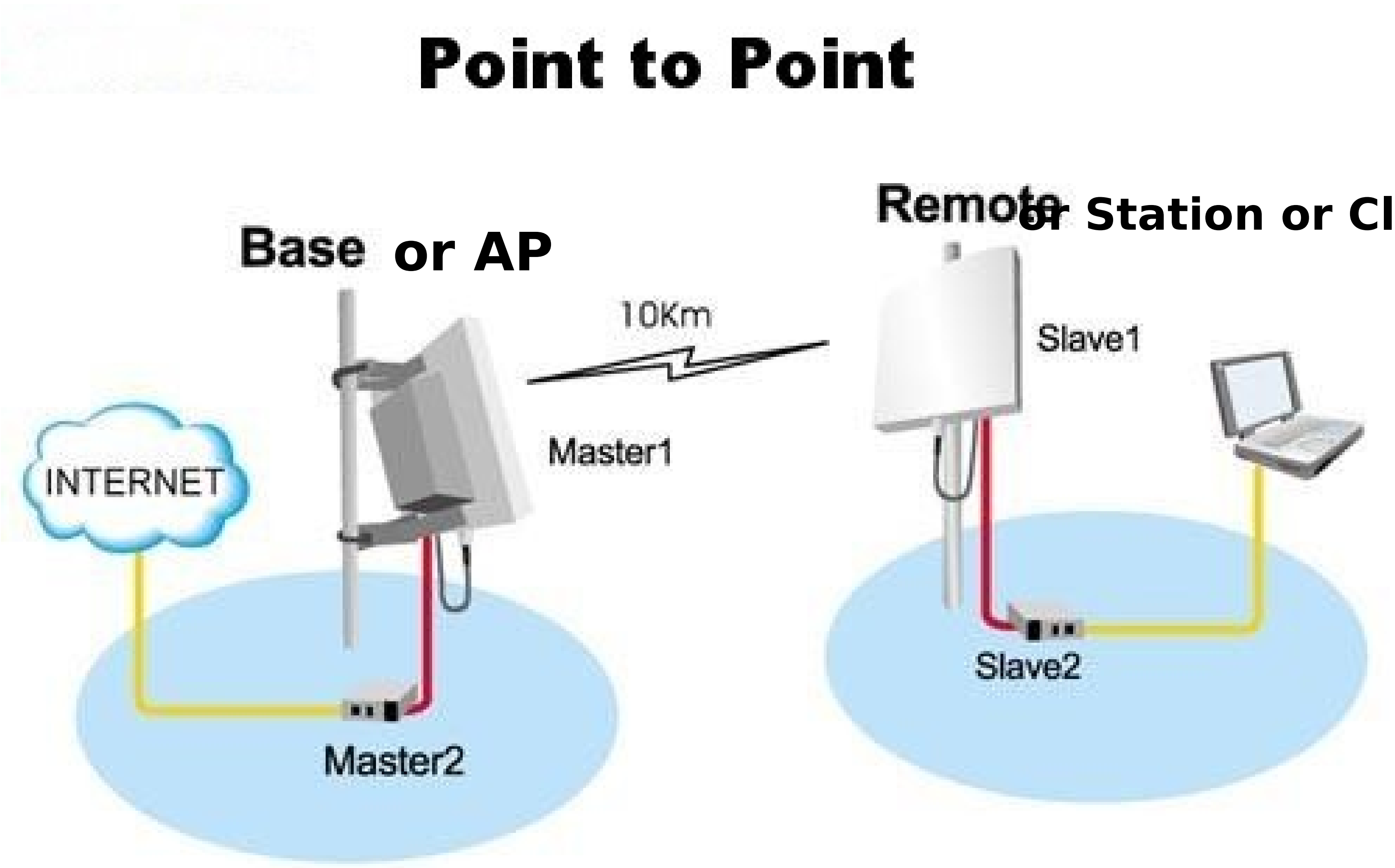
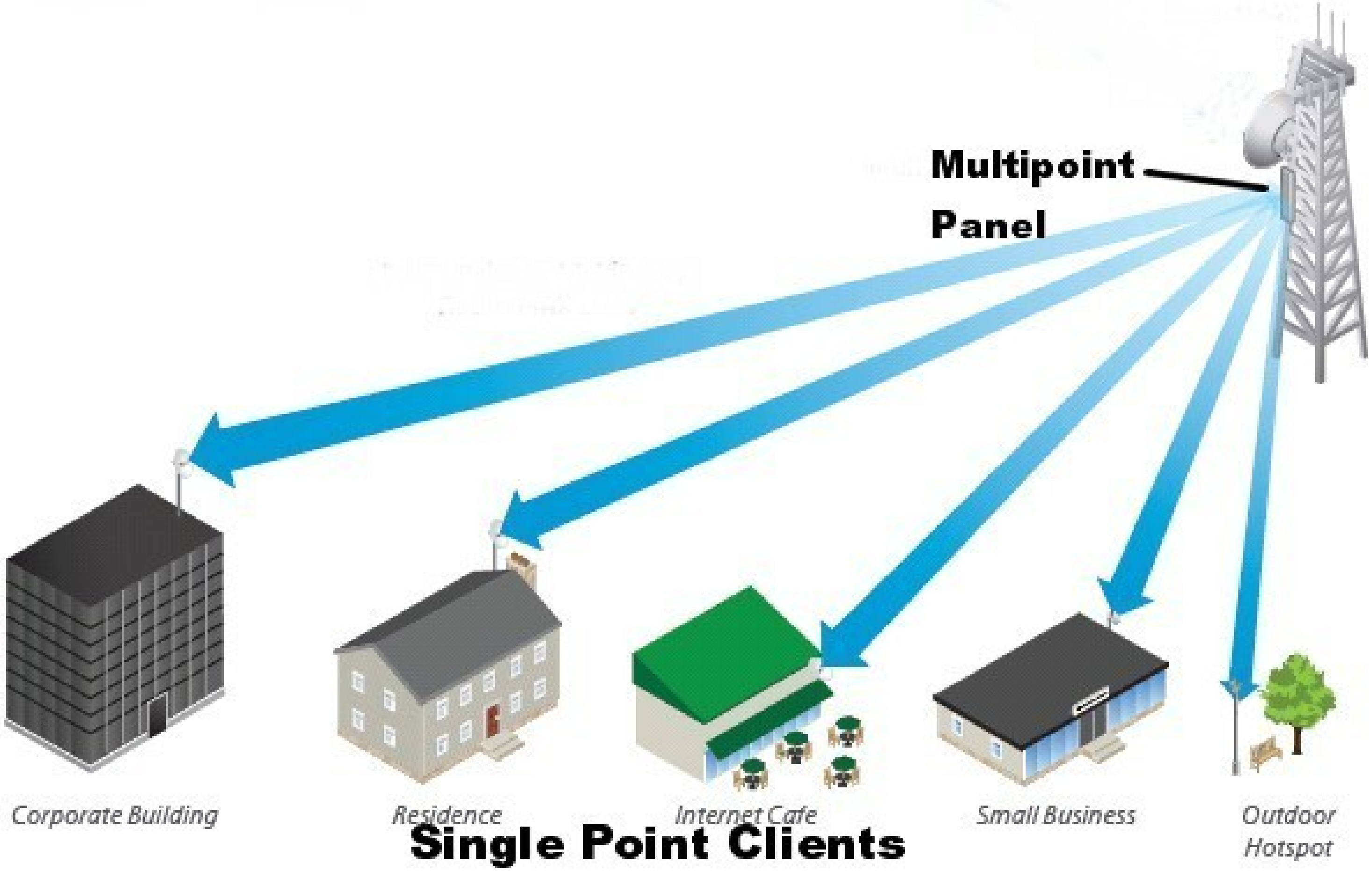
Short Hop Microwave



or AP

or Station or Client

PtMP - Point to Multi-Point



Multipoint Panel

Single Point Clients

- What this class isn’t:
  - Home brew turn a satellite TV dish into a Ham system or some such.
  - A class on how to steal/share commercial internet service (that’s theft of service, a no-no)

- What this class is:
  - How to use commercially available equipment to transport IP* over varying distances.
  - Some ideas and examples of what you can do with this capability.

Downloads

N7KUW.COM/hop

Copy of this presentation (pptx & pdf)
Programming info & text files for Mikrotik

N7KUW.COM/CommAcad

My other classes

Contact Info: Carl Leon N7KUW
Carl@n7kuw.com

HamWAN Relay To This Room

Will detail at end of class

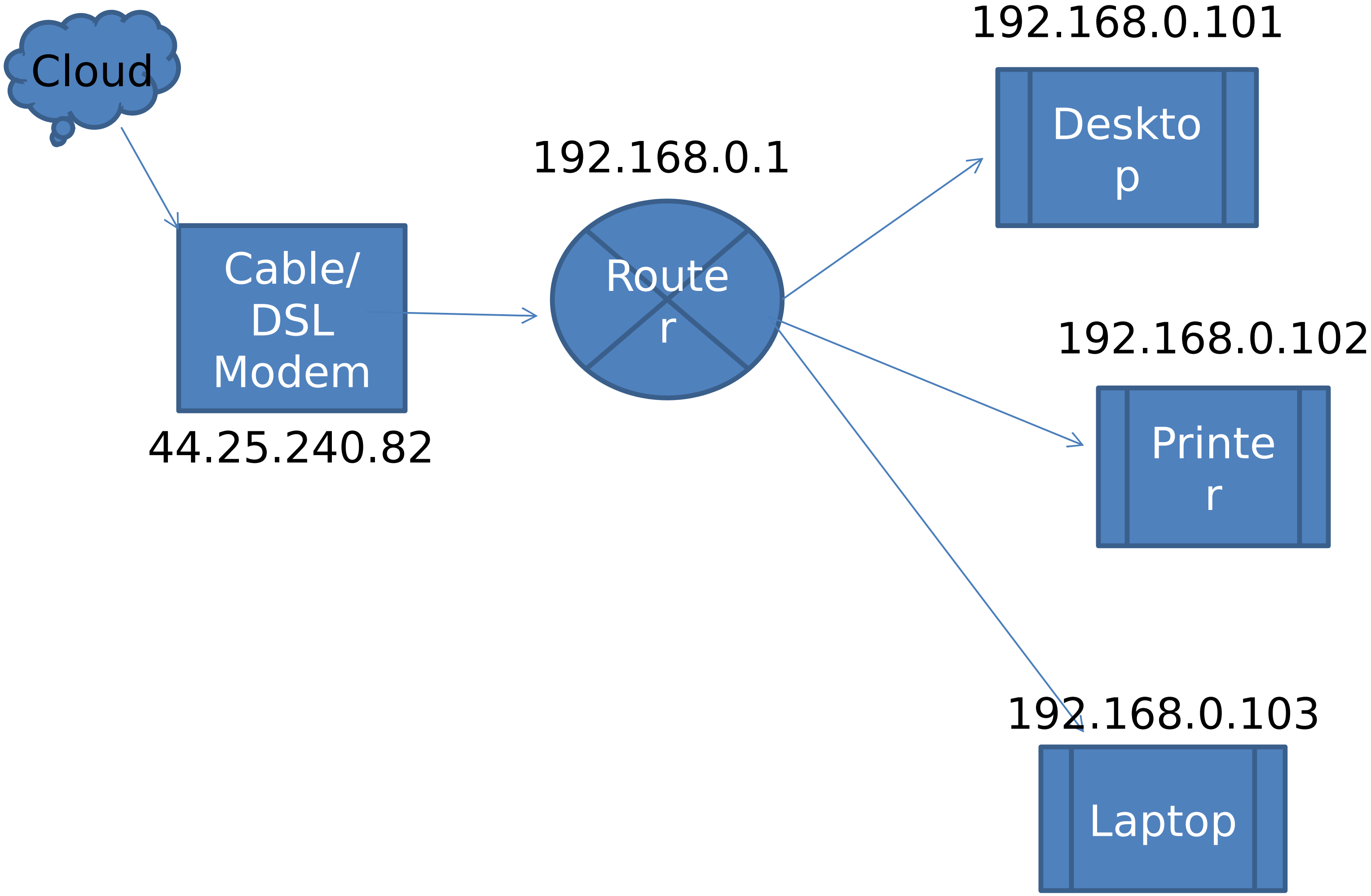
- Wireless ssid:

CA44 = An outside world / internet routable 44. series IP address from HamWAN

CA192 = A 192.x.x.x LAN with NAT to 44. series HamWAN address

Password: CommAcad2019

Very Basic Network



Cloud

Cable/ DSL Modem

44.25.240.82

192.168.0.1

Route r

192.168.0.101

Deskto p

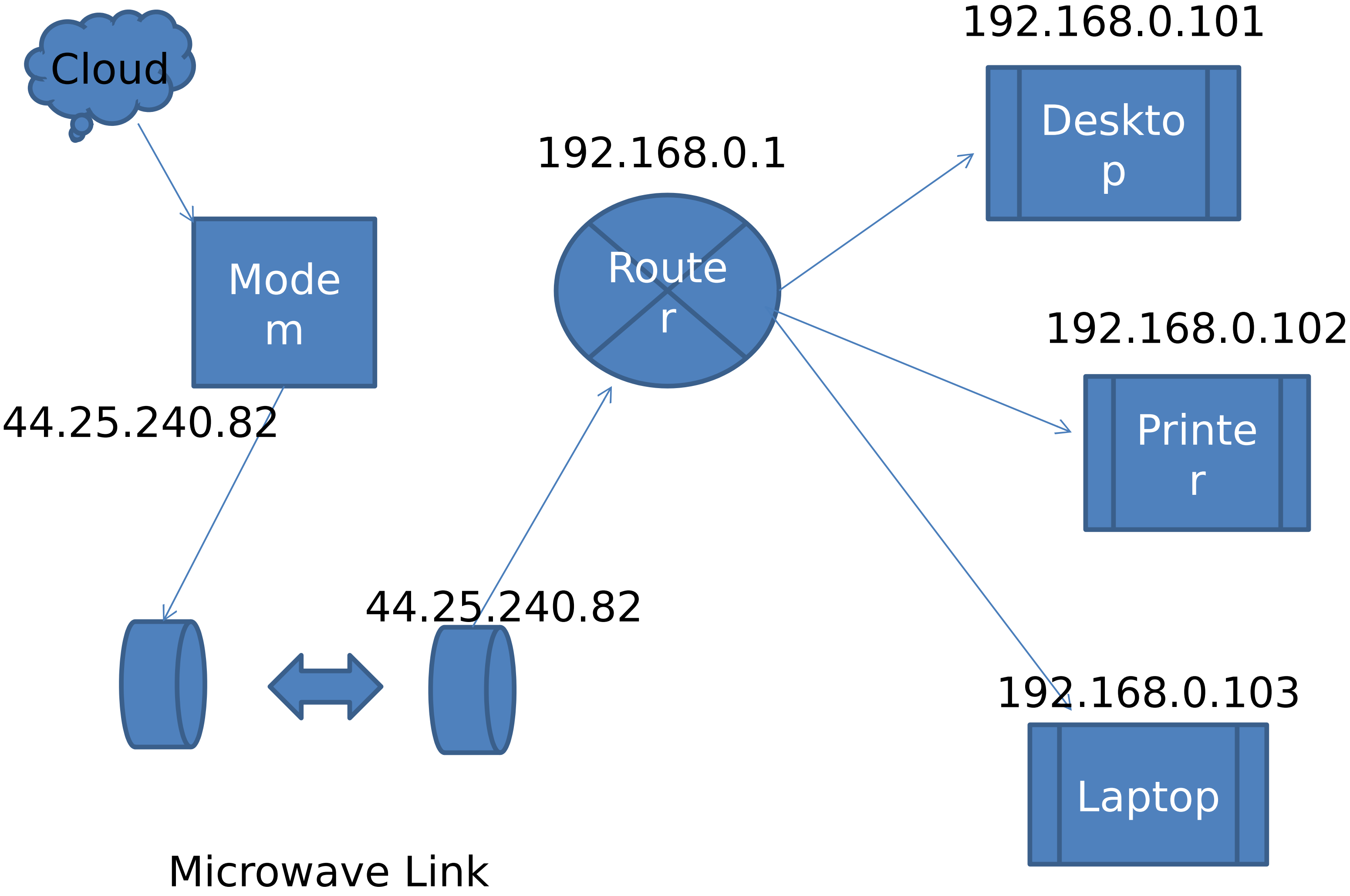
192.168.0.102

Printe r

192.168.0.103

Laptop

Basic Network



Cloud

Mode
m

44.25.240.82

192.168.0.1

Route
r

44.25.240.82

Microwave Link

192.168.0.101

Deskto
p

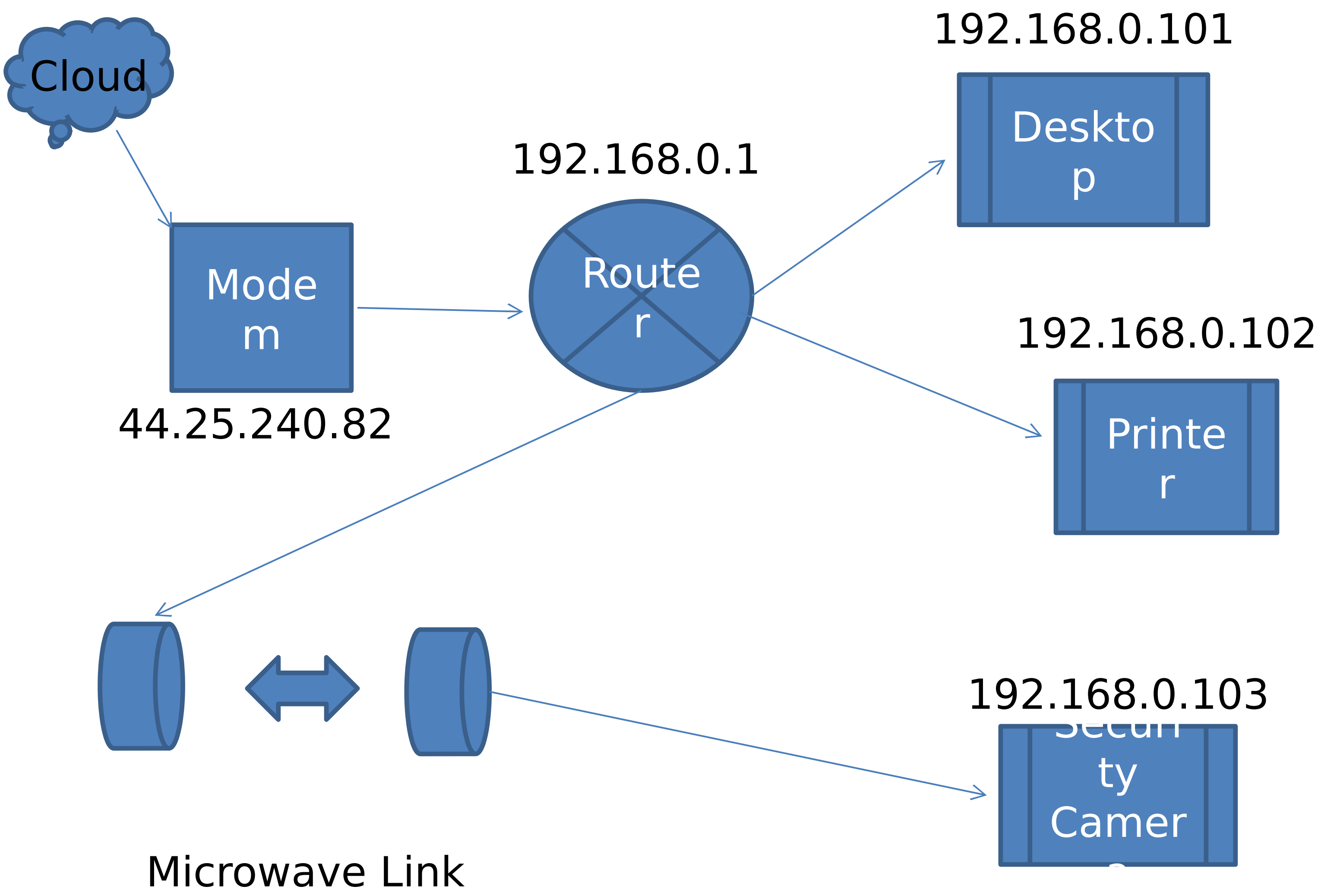
192.168.0.102

Printe
r

192.168.0.103

Laptop

Basic Network



Cloud

Modem

44.25.240.82

192.168.0.1

Router

192.168.0.101

Desktop

192.168.0.102

Printer

192.168.0.103

Security Camera

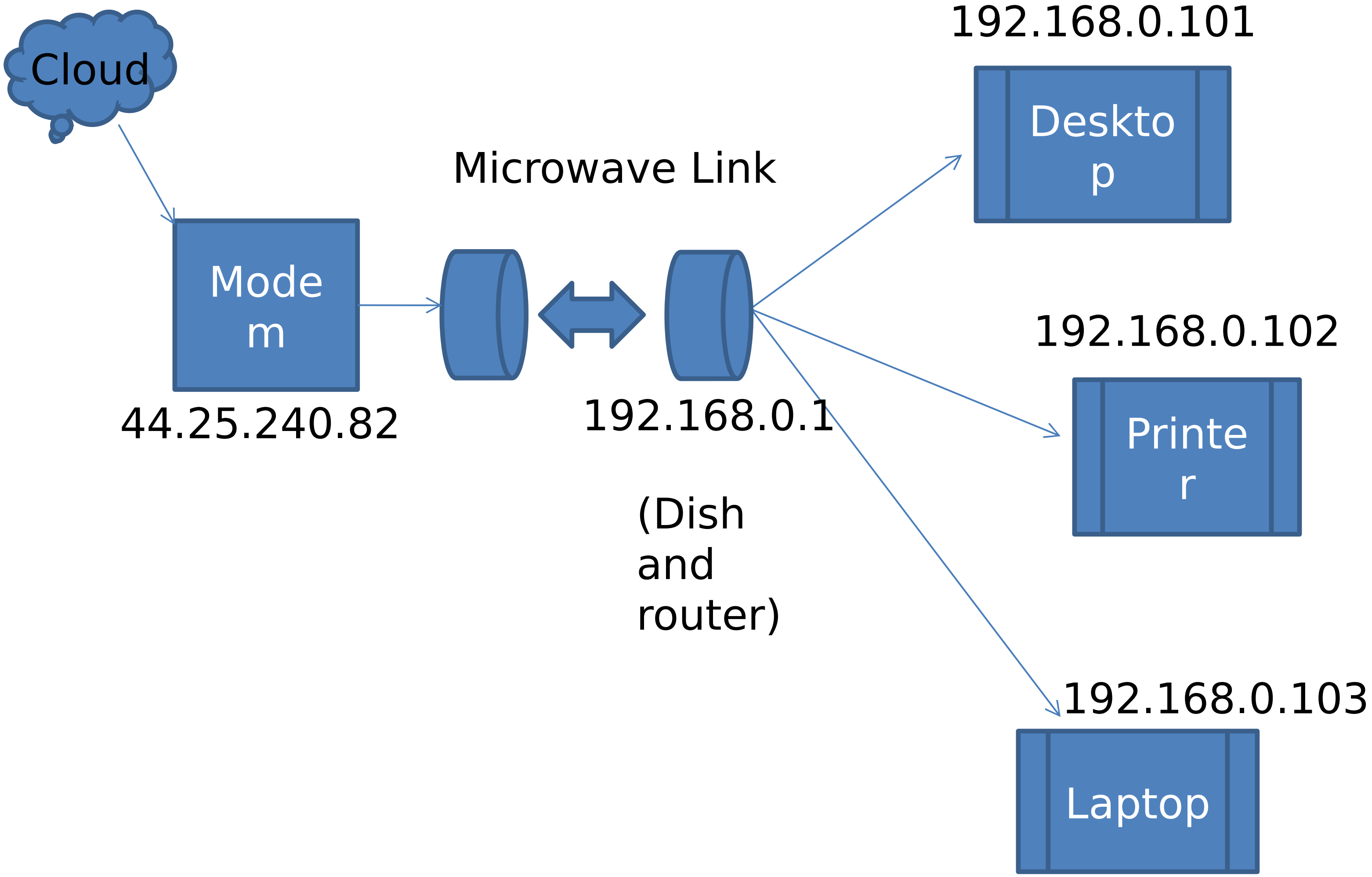
Microwave Link

How complicated it can be…

The microwave devices, whether they are Ubiquiti, Mikrotik, or any of a variety of other brands, almost without exception have a full, built in, router. In the examples I’m showing, we are not using that router – we are programming it to be a complete pass-through, or bridge.

But you could use the router if you

Basic Network



Cloud

Modem

44.25.240.82

Microwave Link

192.168.0.1

(Dish
and
router)

192.168.0.101

Desktop

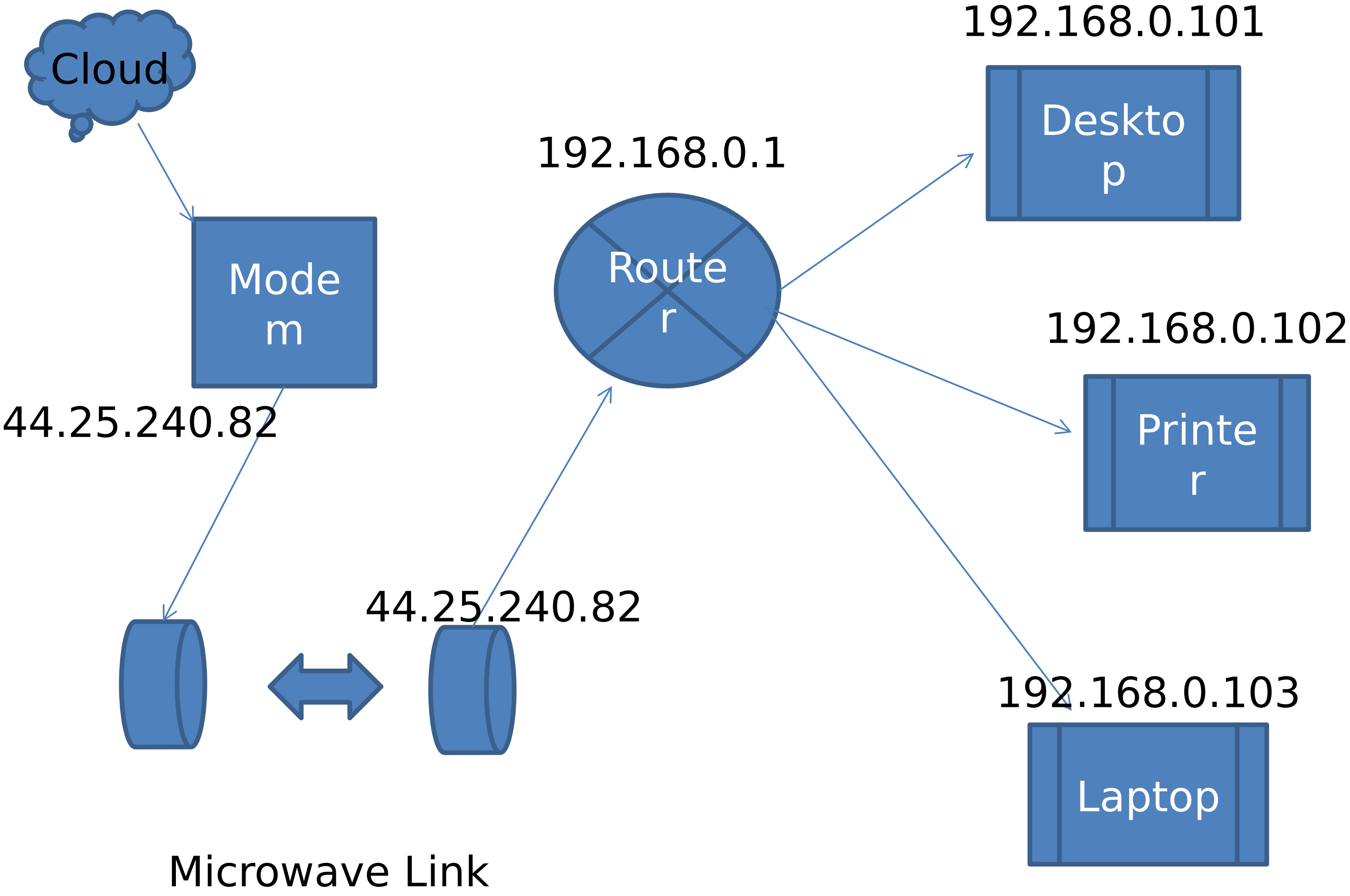
192.168.0.102

Printer

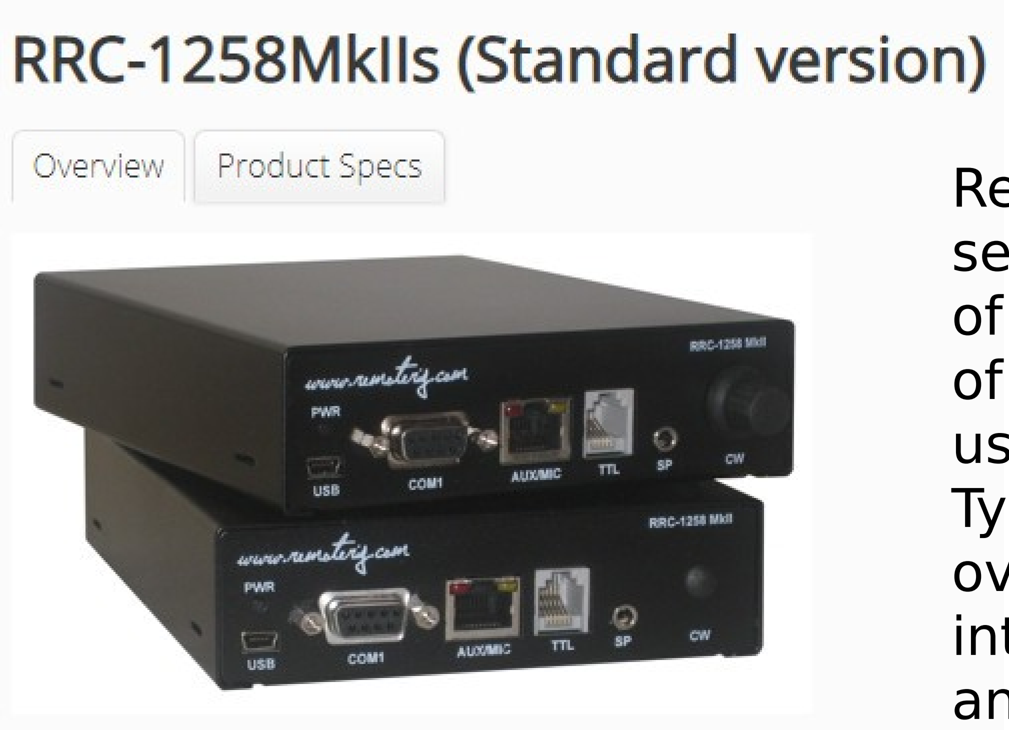
192.168.0.103

Laptop

Basic Network



IP Doesn’t have to be a “network”



RRC-1258MkIIs (Standard version)

Remote Rig allows you to separate the control head of a radio from the RF part of the radio and remotely use the radio over IP. Typically that would mean over your LAN or over the internet, but I tested this and it worked just fine over a point-to-point microwave relay.

So pretty much anything that uses IP, even if not part of a local or wide

What is a Short Hop?

- For our purposes, anywhere from perhaps 100 feet to 5 or 6 miles. No specific near or far limit.

WHY?

  - Unable to run wire
    - Cost
    - Environment
    - Distance

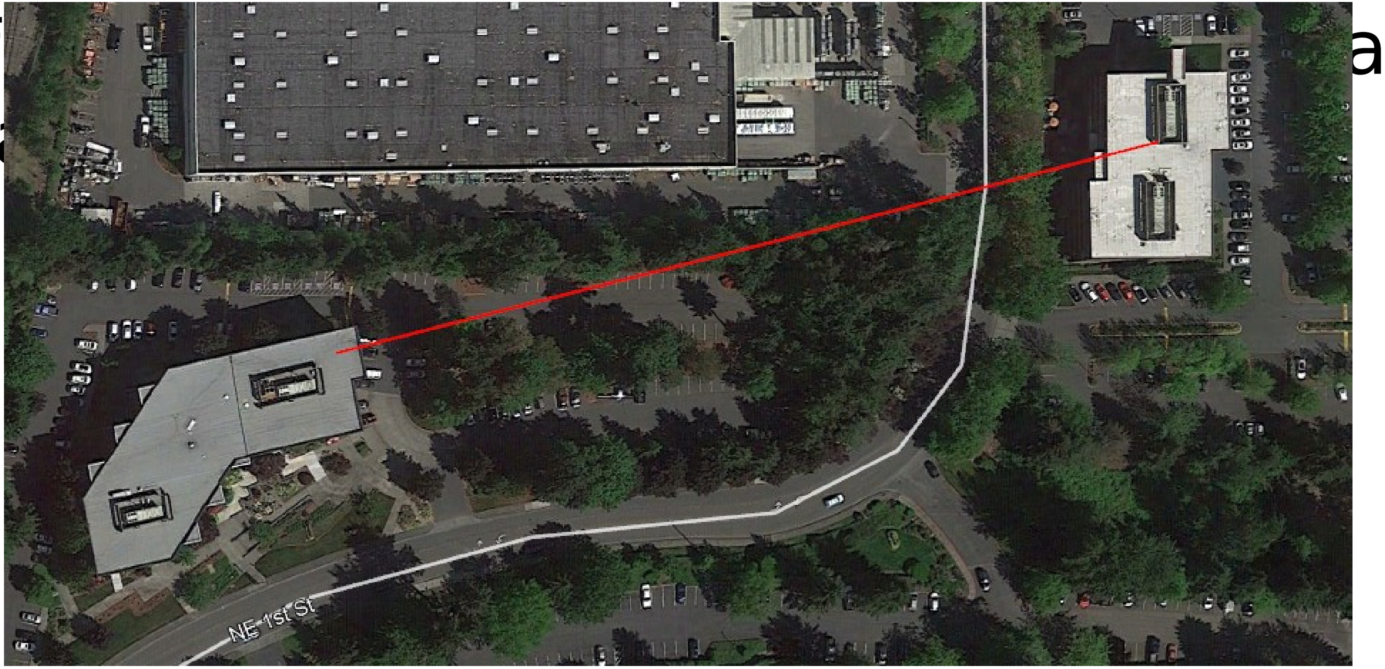
BUT

  - Must have Line Of Sight (LOS) for distances over a few hundred feet. (Real line of sight, you can actually SEE the other end of the link.)

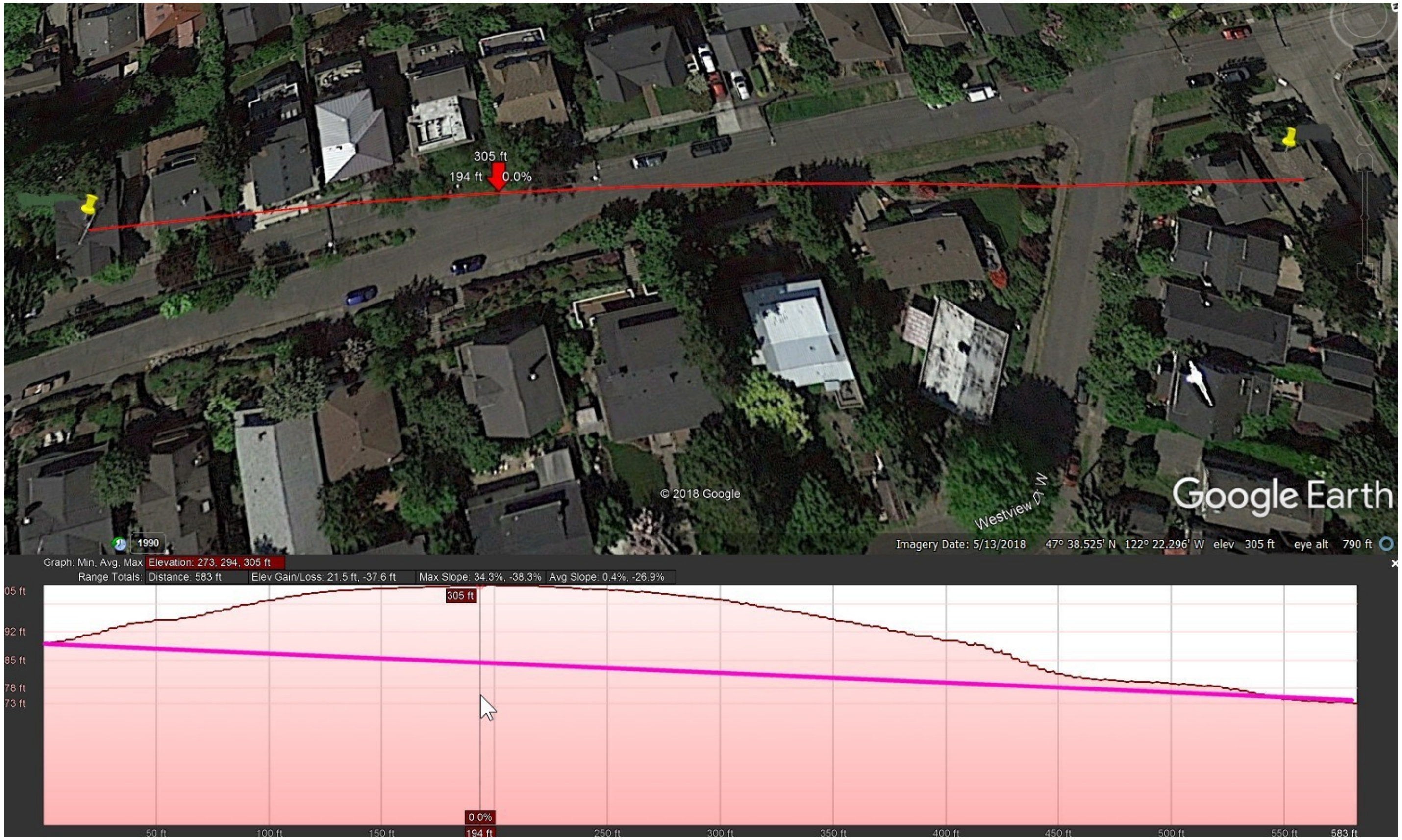
Some Real World Examples

- 1. Business Building to Building
- 2. Relay HamWAN connection
- 3. Field Day here at South Seattle College
- 4. RAMROD
- 5. New house, no internet (oops)
- 6. Large farm property.
- 7. Orcas Island Doe Bay system
- 8. Today’s classroom demo

- A business with offices in two nearby buildings was able to provide connectivity over microwave rather than spend large recurring amounts of money for leased fiber or copper connections between the locations. The one-time cost of installing and setting up the microwave link was off a yea

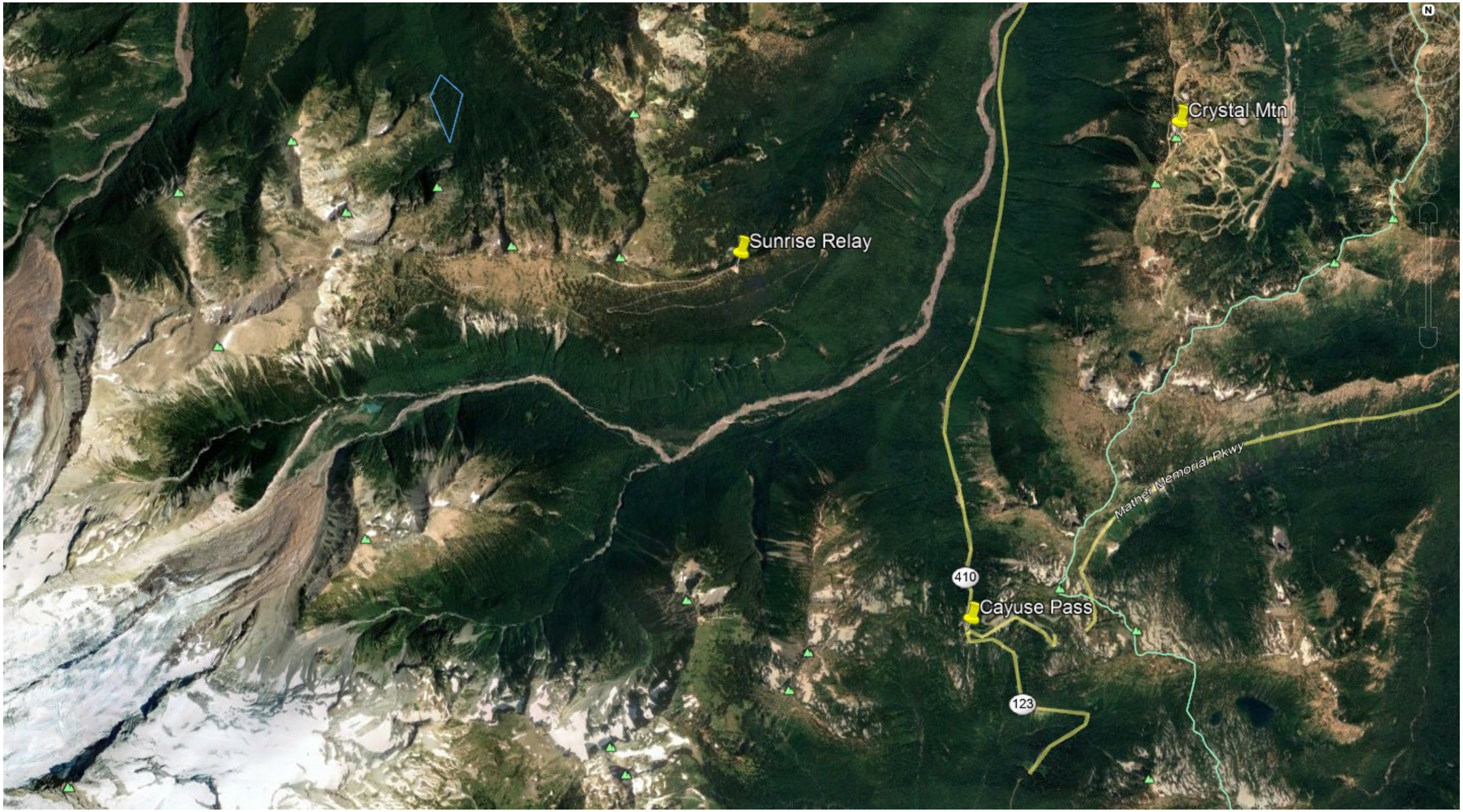


- An amateur operator wants a HamWAN connection at his house, but does not have line of sight to any of the HamWAN sites. Another ham nearby does have a good connection, and there is usable line of sight between the two, so a point-to-point link is set up between them to extend the HamWAN connection.


305 ft
194 ft
0.0%
© 2018 Google
Westview Dr W
Google Earth
1990
Imagery Date: 5/13/2018 47° 38.525' N 122° 22.296' W elev 305 ft eye alt 790 ft
Graph: Min, Avg, Max Elevation: 273, 294, 305 ft
Range Totals: Distance: 583 ft Elev Gain/Loss: 21.5 ft, -37.6 ft Max Slope: 34.3%, -38.3% Avg Slope: 0.4%, -26.9%
05 ft
92 ft
85 ft
78 ft
73 ft
305 ft
0.0%
50 ft
100 ft
150 ft
194 ft
250 ft
300 ft
350 ft
400 ft
450 ft
500 ft
550 ft
583 ft

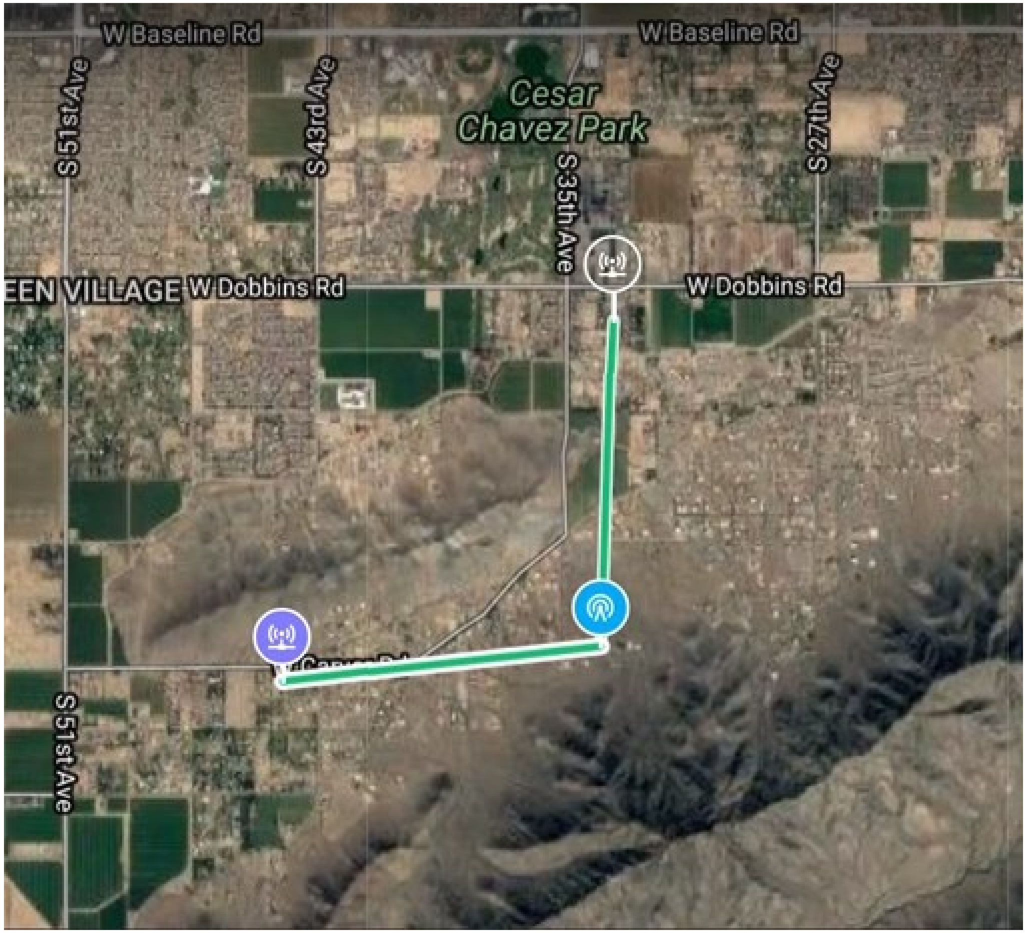
- Seattle ACS, the Puget Sound Repeater Group, and the West Seattle Amateur Radio Club combine to put on Field Day each year in the large field outside, right here at South Seattle College. We use point-to-multipoint microwave links to provide internet connectivity (via HamWAN) to all of the operating tents and trailers here.

High Speed Internet at Cayuse Pass



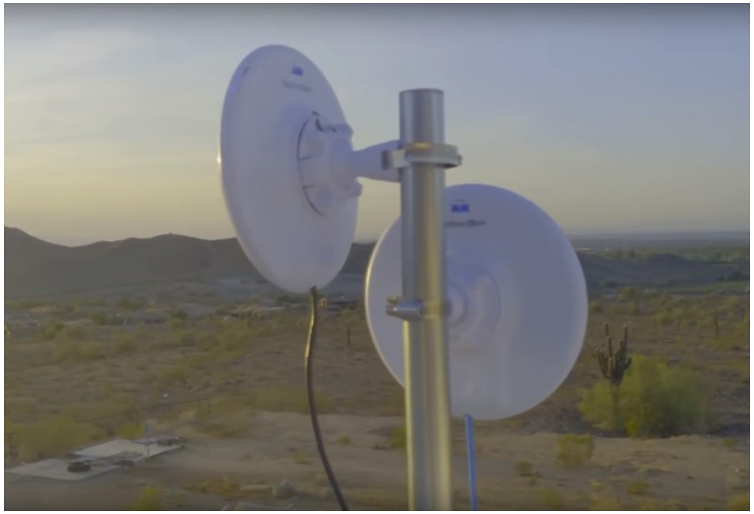
HamWAN was relayed from Crystal Mountain via Sunrise to Cayuse Pass. Sunrise was a standard HamWAN Client, then used a point-to-point relay to Cayuse. This was done in support of RAMROD.

- Two on-line (Youtube) stories of people who bought houses only to discover they could not get high speed internet at the location, so they got service at another location where it was available and then set up short-hop n the locations.



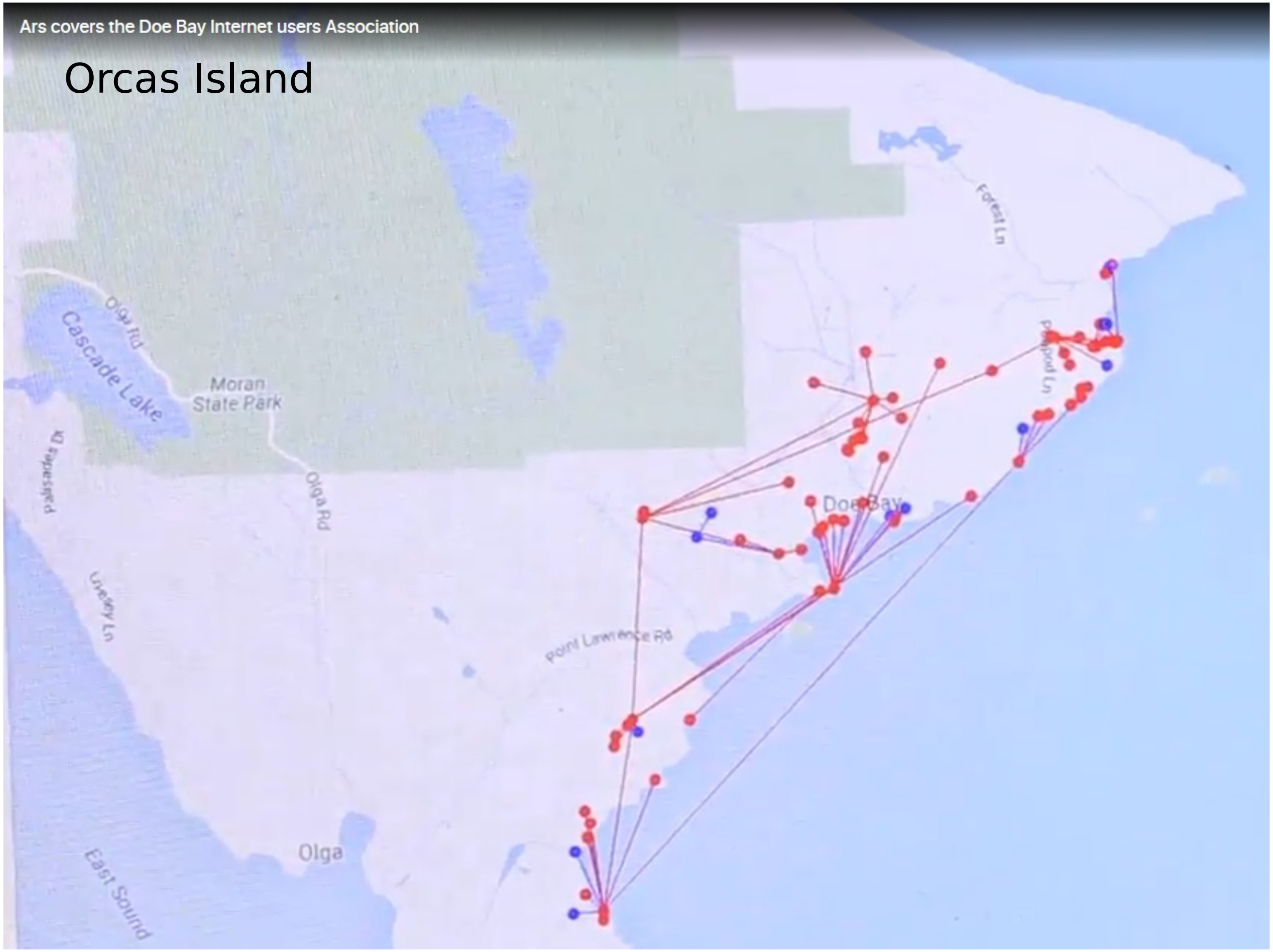
First link is about 1.5 mile.
Second link is about 1.25 mile.

I wouldn’t put the two dishes
So close each other.



- A large property (such as a farm or ranch) where you want to extend your internet service to various outbuildings t wire runs.

A BIG multi-point Ubiquiti network!



Relationship to HamWAN

- Nothing really, other than we are using pretty much the same equipment (possibly by the same manufacturer), and the same technology, to distribute our high speed data. But that does point to one caution, we need to be sure we respectfully share the frequency spectrum, and not cause interference to each other (or others).

What Equipment is Needed?

- Probably the most common brand you will find in online searches is Ubiquiti, which makes a large variety of good, relatively low cost, 2.4 GHz and 5 GHz equipment, as well as some other bands. Mikrotik, which is the equipment used by HamWAN, makes comparable equipment, at comparable cost, that works just as well, but is not as widely known. There are other brands also available. I have slightly more experience with Mikrotik (simply because of HamWAN), but have equipment of both brands here today to display and demonstrate. Ubiquiti is more user friendly to the novice, and you can often find more online help.

- Oh, and full disclosure – I don’t work for either company, I don’t sell equipment, and I’m not getting paid by anyone to suggest or promote equipment. Everything I’m showing you here today is my own personally acquired equipment, or is a Seattle ACS resource.

How Much ?

- Many variables, but at the low end, for a short link, you can buy the components for about $50 (each) up to about $250 (each).

- High end systems can cost in the tens of thousands of dollars.

Part 15 vs Part 97

(Or, unlicensed versus amateur?)

– Amateur (Part 97) (International or ROW* version)
  - Can be hard to find/purchase equipment
  - Cannot (legally) encrypt
  - No business/professional use
  - Has more frequencies available
  - Can use higher power

– Unlicensed (Part 15) (US Only version)
  - Equipment more readily available
  - Power restrictions
  - Uses same frequencies as 2.4 & 5 GHz Wifi
  - Okay to encrypt, okay for business use.

* Rest of World

Only Mikrotik for HamWAN

- If you want equipment that can be used as a HamWAN client, then you MUST have Mikrotik, and you MUST have the international (not US) version.

- HamWAN utilizes the nv2 protocol in the wireless setup (as opposed to 802.11), which is unique to Mikrotik. For that reason, ONLY Mikrotik equipment is compatible with HamWAN.

- HamWAN utilizes Part 97 amateur frequencies for the sector-to-client links, requiring use of the non-US version of equipment. You typically must provide a copy of your amateur license to purchase the non-US version of this equipment, and be VERY specific when ordering it.

Available Frequencies

5GHz spectrum				Max Power		
WiFi Channel	Ctr Freq	Bandwidth	Freq Range	AP	Client	Remarks
36	5180	20	5170-5190	1W	250mW	6dBi max antenna gain
40	5200	20	5190-5210	1W	250mW	6dBi max antenna gain
44	5220	20	5210-5230	1W	250mW	6dBi max antenna gain
48	5240	20	5230-5250	1W	250mW	6dBi max antenna gain
149	5745	20	5735-5755	1 Watt	1 Watt	6dBi max antenna gain
153	5765	20	5755-5775	1 Watt	1 Watt	6dBi max antenna gain
157	5785	20	5775-5795	1 Watt	1 Watt	6dBi max antenna gain
161	5805	20	5795-8515	1 Watt	1 Watt	6dBi max antenna gain
165	5825	20	5815-5835	1 Watt	1 Watt	6dBi max antenna gain
HamWAN Sector Frequencies (point to multi-point) (Amateur Radio Frequencies)						
Name	Center	Low	High	Width		
S1-10	5920	5915	5925	10		
S2-10	5900	5895	5905	10		
S3-10	5880	5875	5885	10		
S1-5	5920	59175	59225	5		
S2-5	5900	58975	59025	5		
S3-5	5880	58775	58825	5		

Specific Equipment

- Ubiquiti LiteBeam AC
- 16dBi 2x2 MIMO
- Multi-Point AP

- (US Version)
- (Ubiquiti is NOT compatible with HamWAN, but is great for point-to-point)

$130

Specific Equipment

- Ubiquiti NBE-M5-16
- High Performance
- Air-MAX Bridge
- NanoBeam M5

- (US Version)
- (Ubiquiti is NOT compatible with HamWAN, but is great for point-to-point)

$73

Specific Equipment

- Mikrotik SXTsq Lite5 RBSXTsq5nD
- International Version
- Can be HamWAN client, or used in PtP, or used as client in PtMP.

$45

Specifications

Product code	RBSXTsqG-5acD (International), RBSXTsqG-5acD-US (USA)
CPU	IPQ-4018, 4 cores, nominal frequency 716 MHz
Size of RAM	256 MB
Storage	16 MB Flash
10/100/1000 Ethernet ports	1
Wireless bands	5 GHz radio
Wireless regulations	Specific frequency range may be limited by country regulations
Operating frequency	International 5150 - 5875 MHz
	USA 5170 - 5250 MHz 5725 - 5835 MHz
Protocols	802.11a/n/ac
Chains	2
Antenna gain	16 dBi
Antenna beam width	23°
Wireless chip model	IPQ-4018
PoE in	Yes
Supported input voltage	10 V - 30 V, passive PoE
Ingress protection	IP55
Dimensions	129 x 129 x 34 mm; package: 255 x 180 x 45 mm
Weight	Unit: 295 g; package: 492 g
Operating temperature	-40 to 70° C
License level	3
Operating System	RouterOS
Max Power consumption	7 W

Wireless specifications

RATE (5 GHz)	Tx (dBm)	Rx (dBm)
6MBit/s	25	-96
54MBit/s	21	-80
MCS0	25	-96
MCS7	20	-75
MCS9	18	-70

QuickMount Pro adjustable mount available separately.

Specific Equipment

Mikrotik RB911G-5HPnD-QRT

QRT-5 Wireless System

International Version

Can be HaWAN client, or used in PtP, or PtMP client or

$153

QRT 5

High power integrated antenna

The QRT 5 is a rugged outdoor flat panel antenna, with a built in RouterBOARD. The device has a 24dBi antenna and a high power 5GHz wireless transmitter.

Inside is the high power RB911 dual chain wireless device (see separate brochure), with high performance, high output power wireless transmitter. It has a Gigabit Ethernet port, to fully utilise the benefit of 802.11n high speed wireless.

Easy to use and quick to deploy, QRT is ideal for point to point links.

Frequencies	4.9-5.875 GHz
Gain	24 ± 1 dBi
VSWR	1.37 : 1
3 dB Beam-Width, H-Plane	10.5°
3 dB Beam-Width, E-Plane, typ.	10.5°
Polarization	Dual, Vertical and horizontal
Port to Port Isolation	-50 dB
Cross polarization, min	-25 dB
Front to Back Ratio, min	35 dB

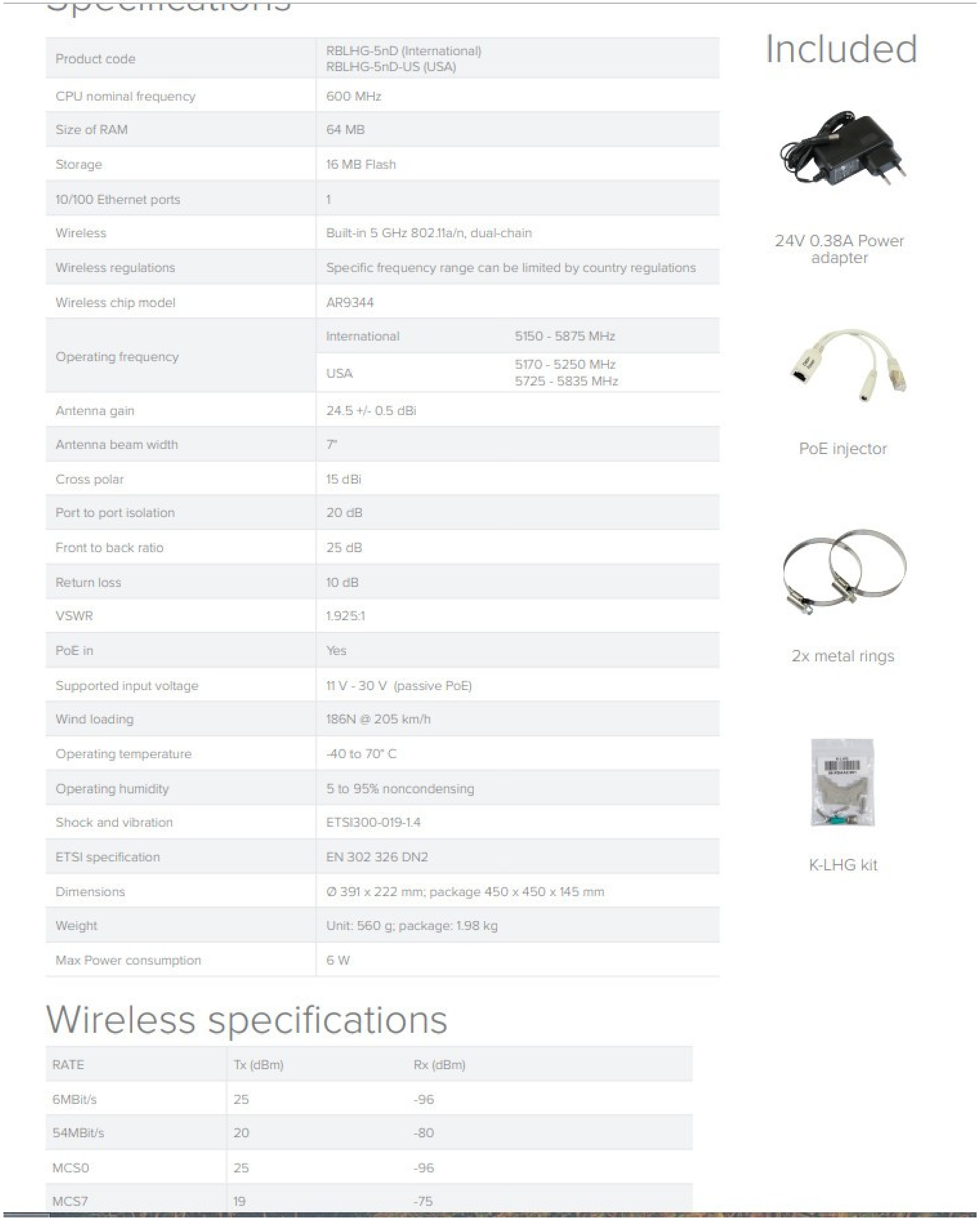
Model	QRT 5 (RB911G-5HPnD-QRT)
Features	1 Ethernet, Gigabit, High power, Dual chain
CPU	Atheros AR9342 600MHz network processor
Memory	64MB DDR onboard memory
Data storage	128MB NAND memory chip
Ethernet	One Gigabit port with Auto-MDI/X
Wireless	Built in 5GHz 802.11a/n (AR9342)
Wireless regulations	Specific frequency range may be limited by country regulations
Extras	beeper, signal and status LEDs, voltage and temperature sensors
Expansion	-
Power options	PoE: 8-30V DC on Ether1 (Non 802.3af).
Unit dimensions	309x320x50mm
Max consumption	11W at 24V
OS	MikroTik RouterOS, Level4 license (supports wireless CPE/PtP and AP mode)
Included	QRT wireless device, precision mounting bracket, U bolts, pole clamp, screw kit, 24V 0.8A power adapter, Gigabit PoE injector

TX power / RX sensitivity	
TX/RX at MCS0	30dBm / -96dBm
TX/RX at MCS7	24dBm / -78dBm
TX/RX at 6Mbit	30dBm / -96dBm
TX/RX at 54Mbit	27dBm / -80dBm
Frequency range	4900-5920MHz

Specific Equipment

- Mikrotik LHG 5 Light Head Grid 5GHz CPE 24.5 dBi grid antenna.
- International Version
- Can be HamWAN client, or used in PtP, or used as client in PtMP

$73



Specifications

Product code	RBLHG-5nD (International) RBLHG-5nD-US (USA)
CPU nominal frequency	600 MHz
Size of RAM	64 MB
Storage	16 MB Flash
10/100 Ethernet ports	1
Wireless	Built-in 5 GHz 802.11a/n, dual-chain
Wireless regulations	Specific frequency range can be limited by country regulations
Wireless chip model	AR9344
Operating frequency	International: 5150 - 5875 MHz USA: 5170 - 5250 MHz, 5725 - 5835 MHz
Antenna gain	24.5 +/- 0.5 dBi
Antenna beam width	7°
Cross polar	15 dBi
Port to port isolation	20 dB
Front to back ratio	25 dB
Return loss	10 dB
VSWR	1.925:1
PoE in	Yes
Supported input voltage	11 V - 30 V (passive PoE)
Wind loading	186N @ 205 km/h
Operating temperature	-40 to 70° C
Operating humidity	5 to 95% noncondensing
Shock and vibration	ETSI300-019-1.4
ETSI specification	EN 302 326 DN2
Dimensions	Ø 391 x 222 mm; package 450 x 450 x 145 mm
Weight	Unit: 560 g; package: 1.98 kg
Max Power consumption	6 W

Included

24V 0.38A Power adapter

PoE injector

2x metal rings

K-LHG kit

Wireless specifications

RATE	Tx (dBm)	Rx (dBm)
6MBit/s	25	-96
54MBit/s	20	-80
MCS0	25	-96
MCS7	19	-75

Specific Equipment

- Mikrotik DynaDish5 (RBDynaDishG-5HzcD)
- International Version
- Can be HamWAN client, or used in PtP, or as P2MP client
- Longer Range

$155

Specifications

Product code	RBDynaDishG-5HacD
CPU	QCA9557 720 MHz
Size of RAM	128 MB
10/100/1000 Ethernet ports	1
Wireless	Built-in 5 GHz 802.11ac, dual-chain
Frequency range	4920 - 6100 MHz (Operating range limited by Country Regulations)
Antenna gain	25 dBi
Antenna beam width	8°
Wireless chip model	QCA9892
Wireless regulations	Specific frequency range may be limited by country regulations
Port to port isolation	23 db
Return loss	< 15 db
VSWR	1.5
PoE in	Yes
Supported input voltage	11V - 60V passive PoE or 802.3af/at with unshielded cable
Voltage Monitor	Yes
PCB temperature monitor	Yes
CPU temperature monitor	No
Dimensions	Ø 404 mm, height 175 mm (without mount)
License level	3
Operating System	RouterOS
Max Power consumption	9 W
Supported channels	20/40/80 MHz

Included

24 V 0.8 A power adapter

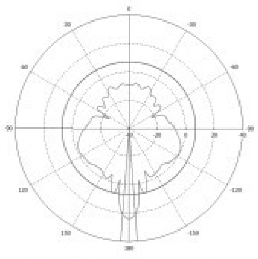
Precision mount

U Kit

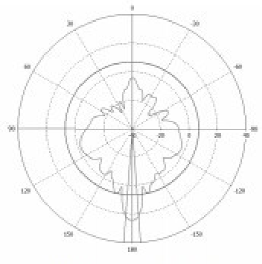
Gigabit PoE injector

Wireless specifications

RATE	Tx (dBm)	Rx (dBm)
6MBit/s	31	-96
54MBit/s	28	-81
MCS0	30	-96
MCS7	27	-77
MCS9	22	-72



Horizontal polarization



Vertical polarization

How Do We Make It Happen?

1. **Verify line of sight signal path.**
   - **Google Earth Elevation Profile and headings**
   - **Compass**
   - **Binoculars**
   - **Chain saw**
2. Determine best equipment for your needs.
3. Purchase equipment.
4. Unpack, set up, program and test equipment ALL AT THE SAME LOCATION!
5. Install local end in final configuration, then test remote end while still local.
6. Install remote end. Find, then peak signal.
   - 3 axis to align, horizontal, vertical, rotational.

   - Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

How Do We Make It Happen?

- Fresnel Zone (@5.9GHz)

0.25 Mi, r = 7.5 feet (11 fee

0.5 Mi, r = 10.6 feet (16 fee

1 Mi, r = 15 feet (23 feet)

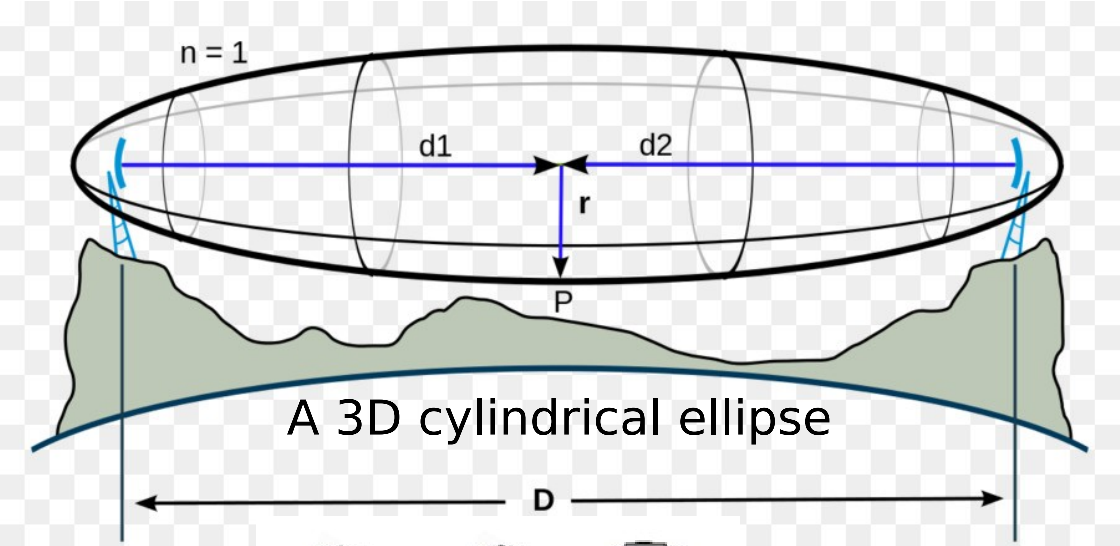
2 Mi, r = 21.2 feet (32 feet)

3 Mi, r = 25.9 feet (40 feet)

4 Mi, r = 29.9 feet (47 feet)

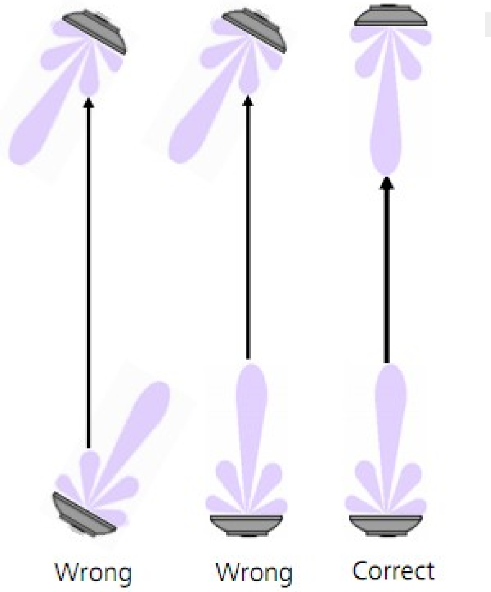
23 Mi, r= 72 feet (111 feet)

(lower freq-larger radius – 2.4Ghz)



A 3D cylindrical ellipse

- Side Lobes

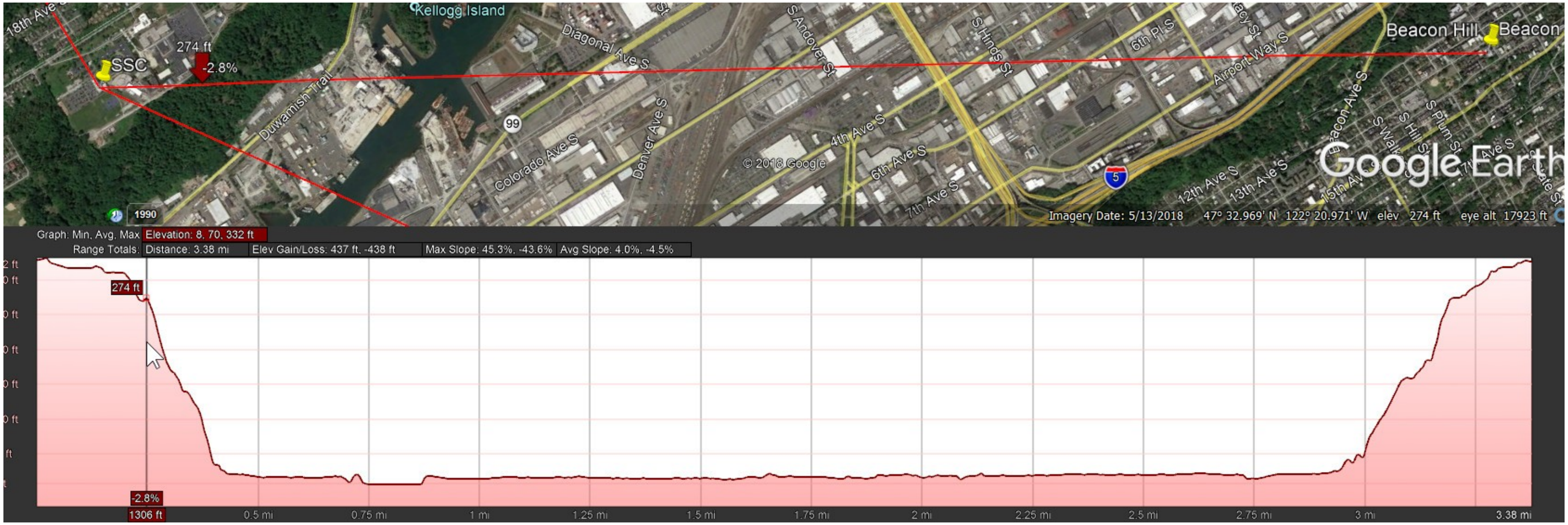


Google Earth

- Accurately mark both ends of the path

  (SSC to Beacon is my example shot)
- Note distance and bearing
  - 30.68 degrees (true), 3.36 miles
- Do elevation profile
  - SSC 329 feet, Beacon 327 feet (ground level)
  - SSC on 3 story bldg, Beacon on 11 story bldg
    - (~ 40 ft = 369 ft) (~110 ft = 437 ft)

Elevation Profile

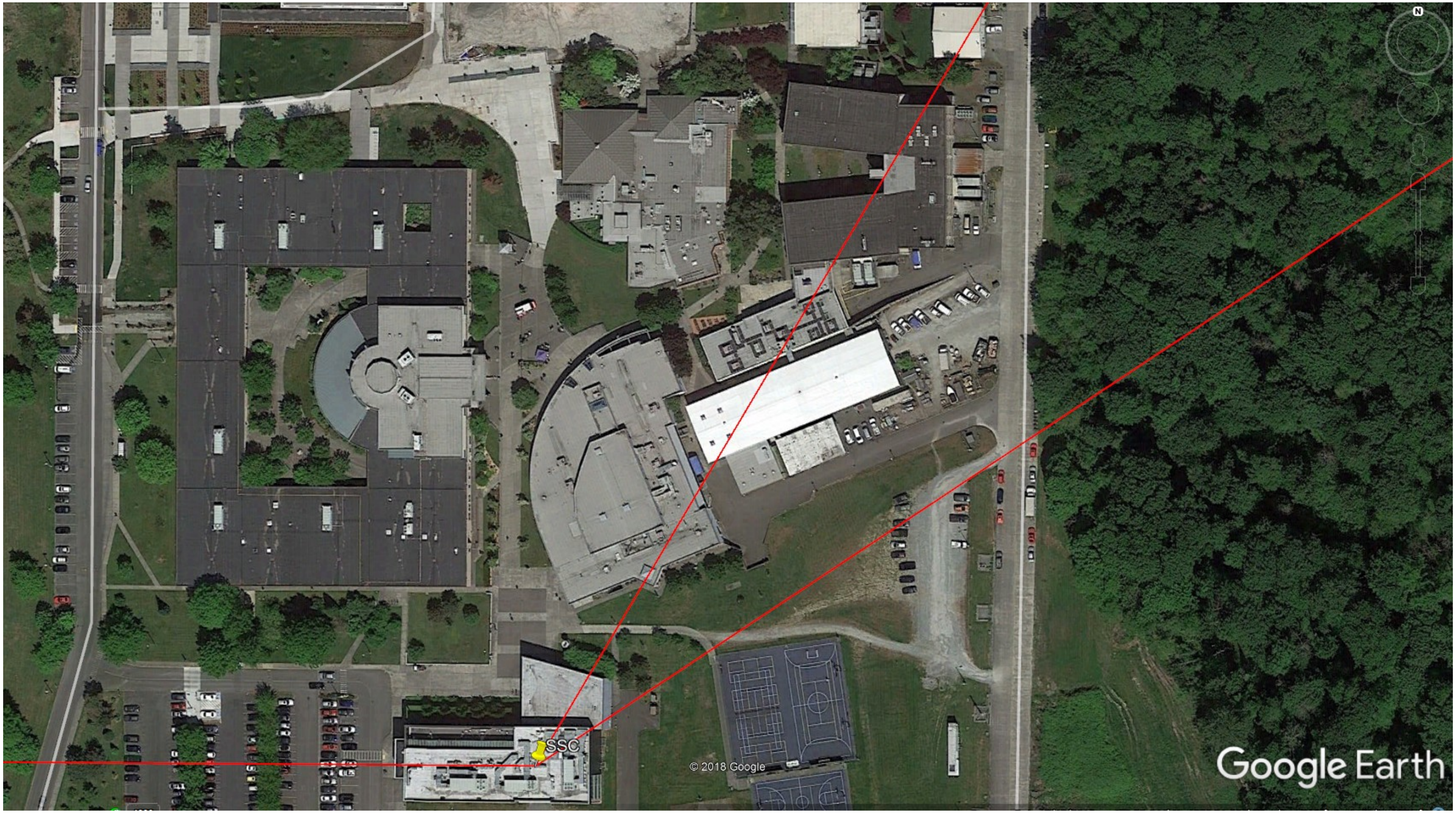


Imagery Date: 5/13/2018 47° 32.969' N 122° 20.971' W elev 274 ft eye alt 17923 ft

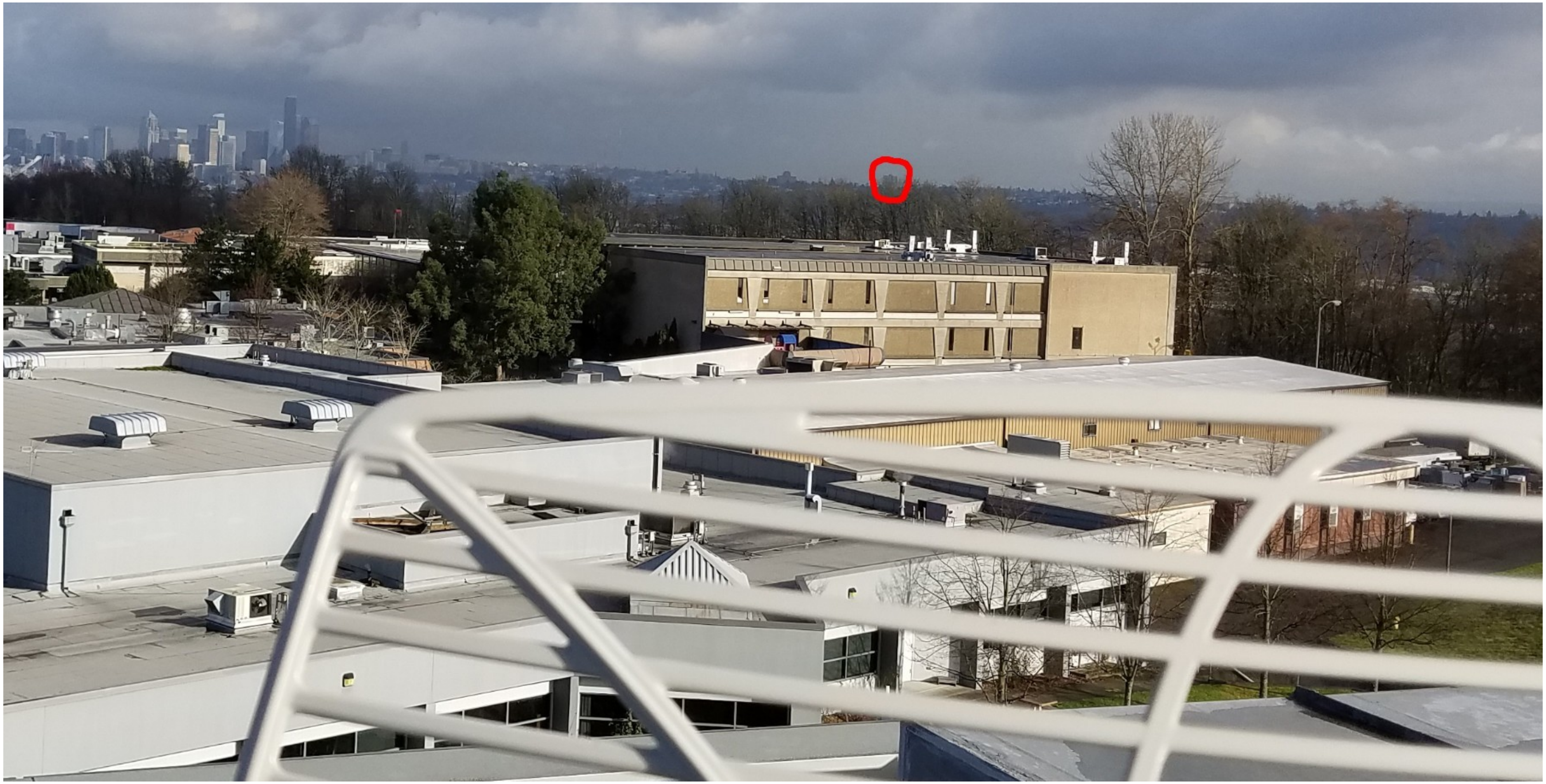
Graph: Min, Avg, Max Elevation: 8, 70, 332 ft

Range Totals: Distance: 3.38 mi | Elev Gain/Loss: 437 ft, -438 ft | Max Slope: 45.3%, -43.6% | Avg Slope: 4.0%, -4.5%

Note surroundings



Line of Sight!



How Do We Make It Happen?

- 1. Verify line of sight signal path.
  - Google Earth Elevation Profile and headings
  - Compass
  - Binoculars
  - Chain saw

  2. Determine best equipment for your needs.

  Bigger & better is always better, but you may have to go smaller due to cost or space to install, or other factors. Get the best you can.

  3. Purchase equipment.

  4. Unpack, set up, program and test equipment ALL AT THE SAME LOCATION!

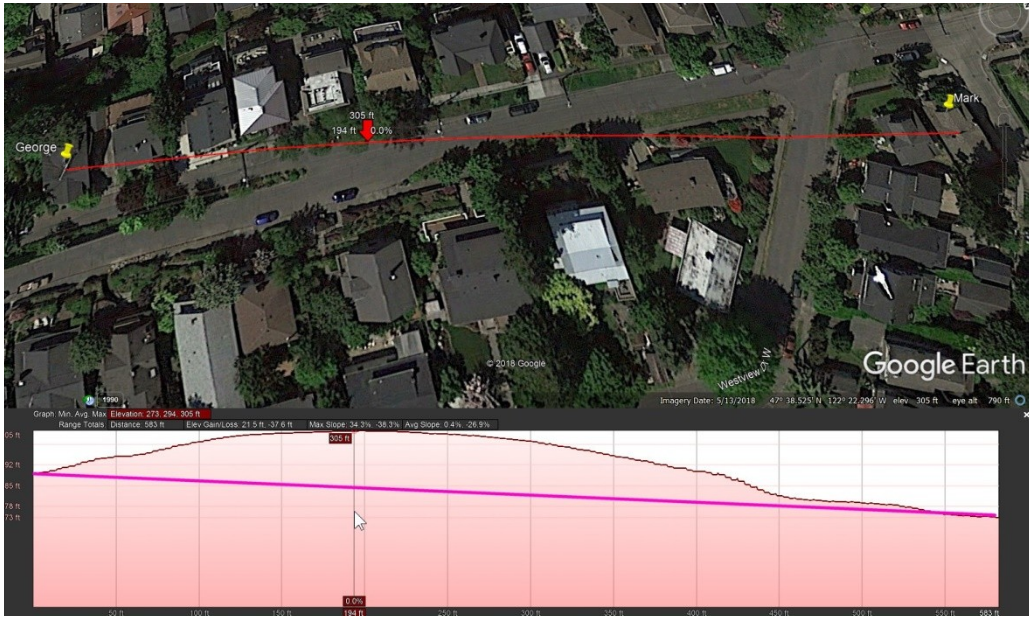
  5. Install local end in final configuration, then test remote end while still local.

  6. Install remote end. Find, then peak signal.

    - 3 axis to align, horizontal, vertical, rotational.

    - Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

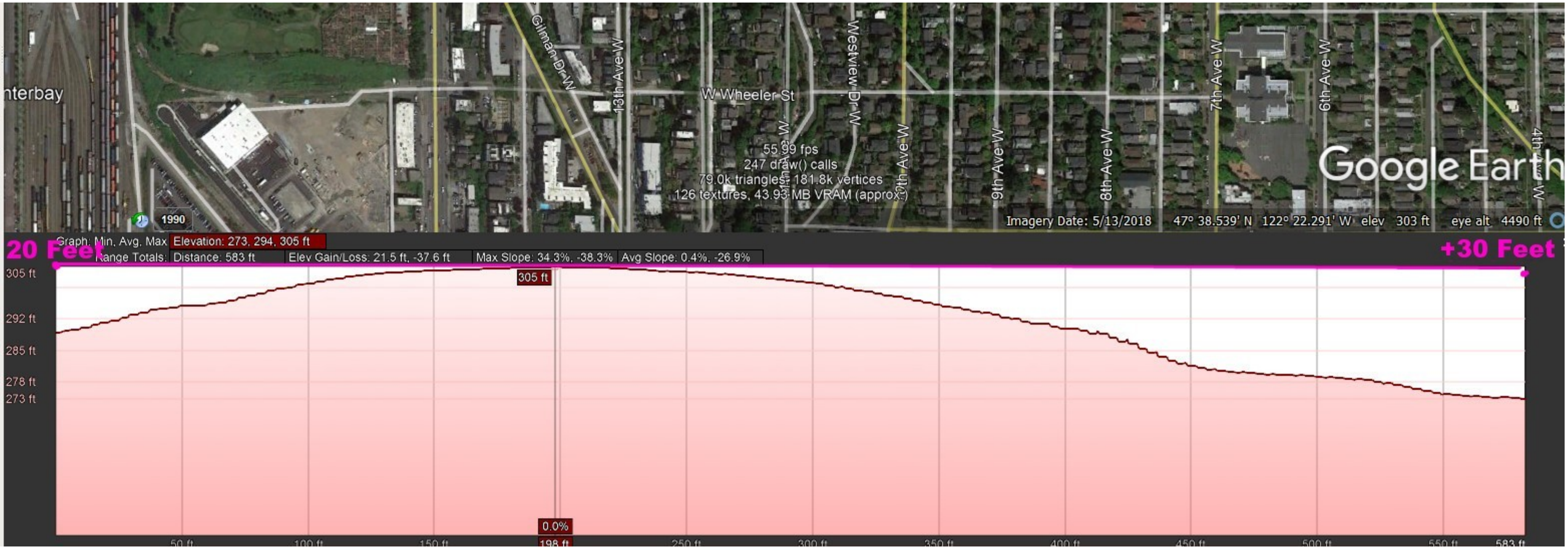
One More Example



Imagery Date: 5/13/2018 47° 38.525' N 122° 22.296' W elev 305 ft eye alt 790 ft

Graph: Min, Avg, Max Elevation: 273, 294, 305 ft

Range Totals: Distance: 583 ft Elev Gain/Loss: 21.5 ft, -37.6 ft Max Slope: 34.3%, -38.3% Avg Slope: 0.4%, -26.9%

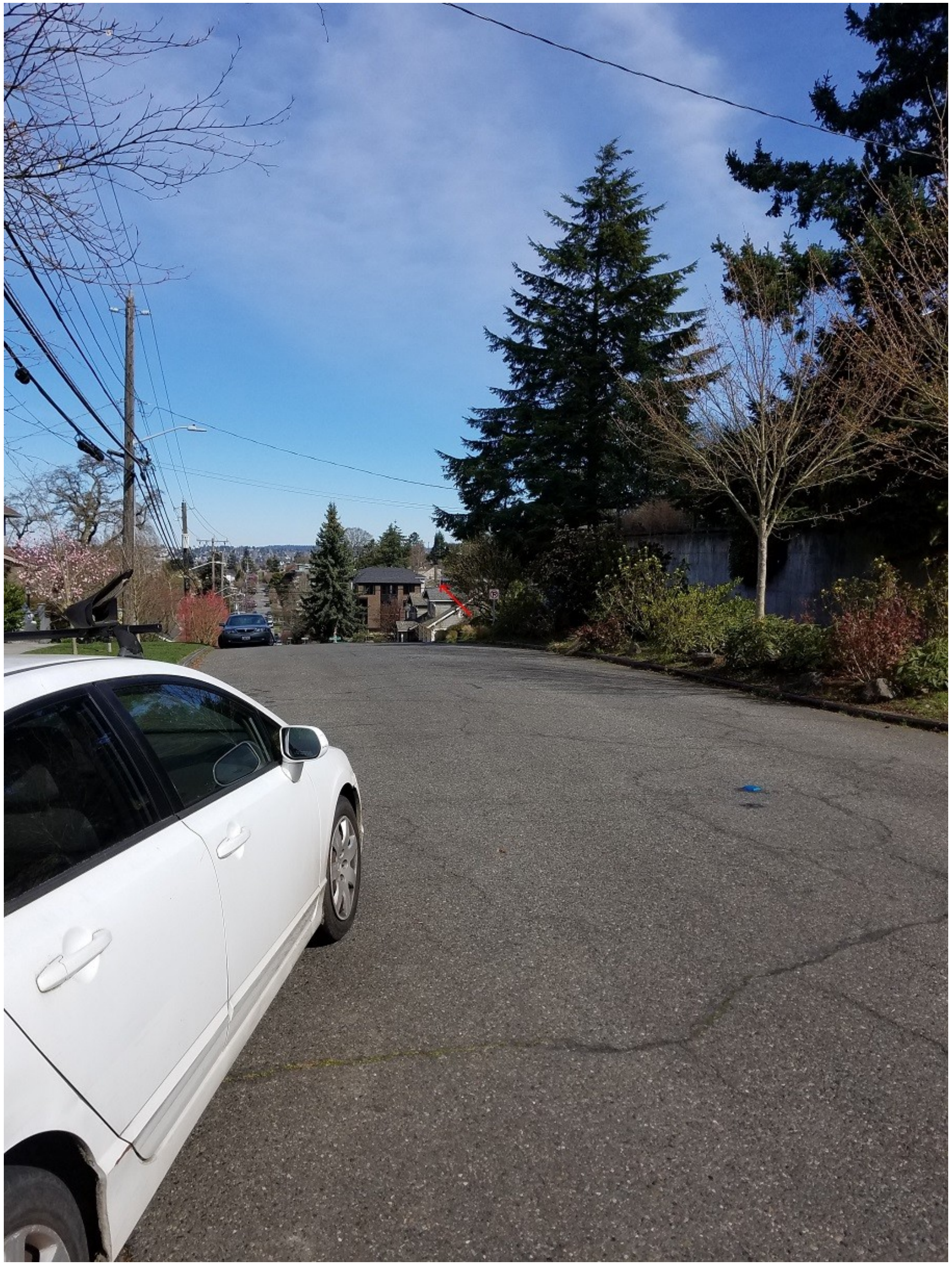


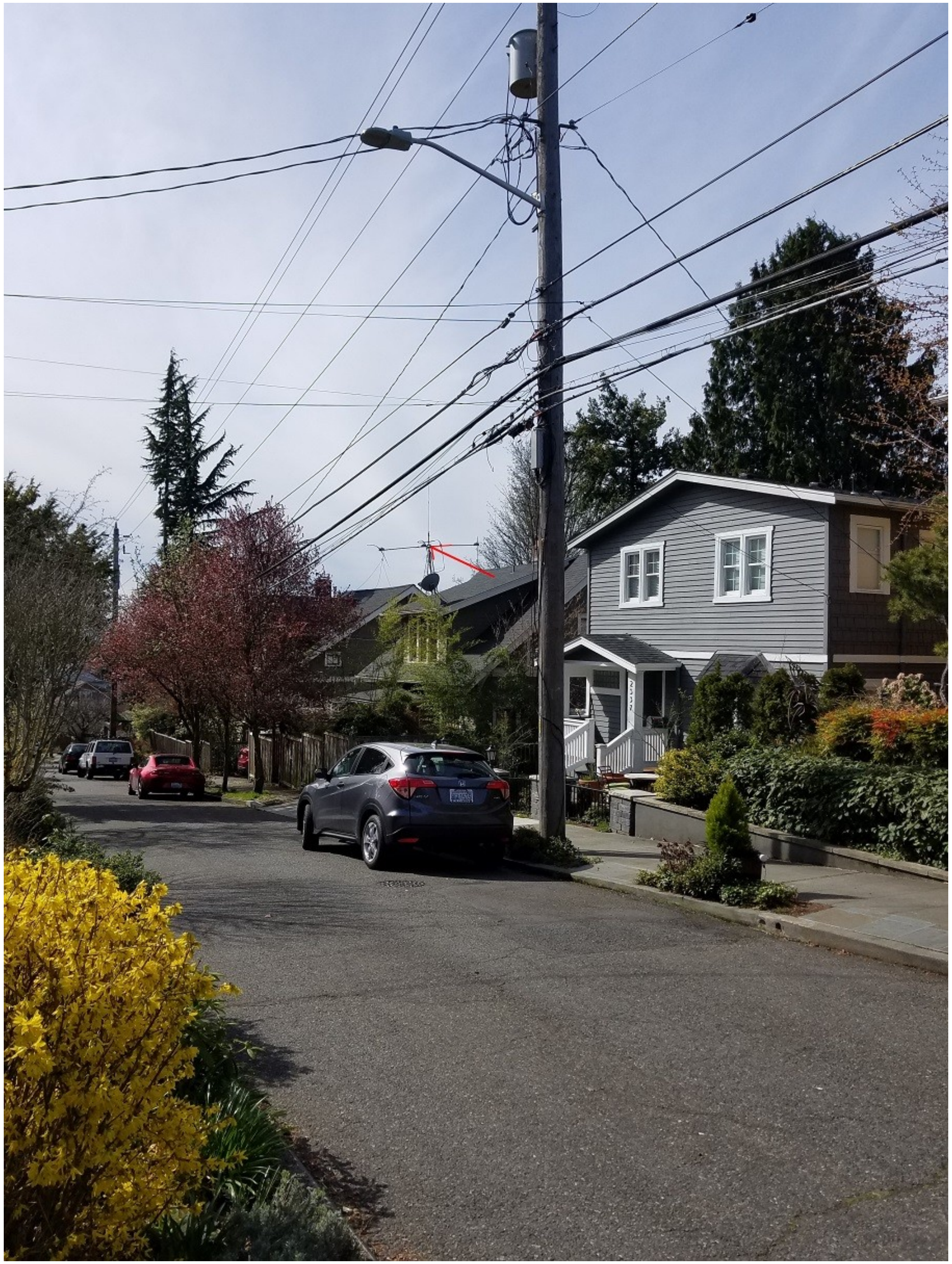
55.99 fps
247 draw() calls
79.0k triangles, 181.8k vertices
126 textures, 43.93 MB VRAM (approx.)

Imagery Date: 5/13/2018 47° 38.539' N 122° 22.291' W elev 303 ft eye alt 4490 ft

Graph: Min, Avg, Max Elevation: 273, 294, 305 ft

Range Totals: Distance: 583 ft Elev Gain/Loss: 21.5 ft, -37.6 ft Max Slope: 34.3%, -38.3% Avg Slope: 0.4%, -26.9%





How Do We Make It Happen?

- **1. Verify line of sight signal path.**
  - **Google Earth Elevation Profile and headings**
  - **Compass**
  - **Binoculars**
  - **Chain saw**

2. Determine best equipment for your needs.

Overkill is okay if you can afford it.

3. Purchase equipment.

MAKE SURE YOU GET INTERNATIONAL VERSION if for HamWAN

Otherwise, it doesn’t matter, US version may be preferred.

4. Unpack, set up, program and test equipment ALL AT THE SAME LOCATION!

5. Install local end in final configuration, then test remote end while still local.

6. Install remote end. Find, then peak signal.

- 3 axis to align, horizontal, vertical, rotational.

- Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

Where to Order

- Streakwave and/or Baltic Networks
  - Might cost a bit more, but well worth it to assure International version (for HamWAN use).
- Amazon or eBay
  - But getting international (non-US) version can be challenging (if equipment will be used with HamWAN). For local P2P use, US version is fine.
  - Typically faster to obtain
  - Maybe less expensive

How Do We Make It Happen?

- **1. Verify line of sight signal path.**
  - **Google Earth Elevation Profile and headings**
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  - **Binoculars**
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  - 3 axis to align, horizontal, vertical, rotational.

  - Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

How Do We Make It Happen?

- **1. Verify line of sight signal path.**
  - **Google Earth Elevation Profile and headings**
  - **Compass**
  - **Binoculars**
  - **Chain saw**

  2. Determine best equipment for your needs.

  Overkill is okay if you can afford it.

  3. Purchase equipment.

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  4. Unpack, set up, program and test equipment ALL AT THE SAME LOCATION!

  5. Install local end in final configuration, then test remote end while still local.

  6. Install remote end. Find, then peak signal.

  - 3 axis to align, horizontal, vertical, rotational.

  - Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

How Do We Make It Happen?

- **1. Verify line of sight signal path.**
  - **Google Earth Elevation Profile and headings**
  - **Compass**
  - **Binoculars**
  - **Chain saw**

2. Determine best equipment for your needs.

Overkill is okay if you can afford it.

3. Purchase equipment.

MAKE SURE YOU GET INTERNATIONAL VERSION if for HamWAN

Otherwise, it doesn’t matter, US version is fine.

4. Unpack, set up, program and test equipment ALL AT THE SAME LOCATION!

5. Install local end in final configuration, then test remote end while still local.

6. Install remote end. Find, then peak signal.

- 3 axis to align, horizontal, vertical, rotational (for dual chain, or MIMO).

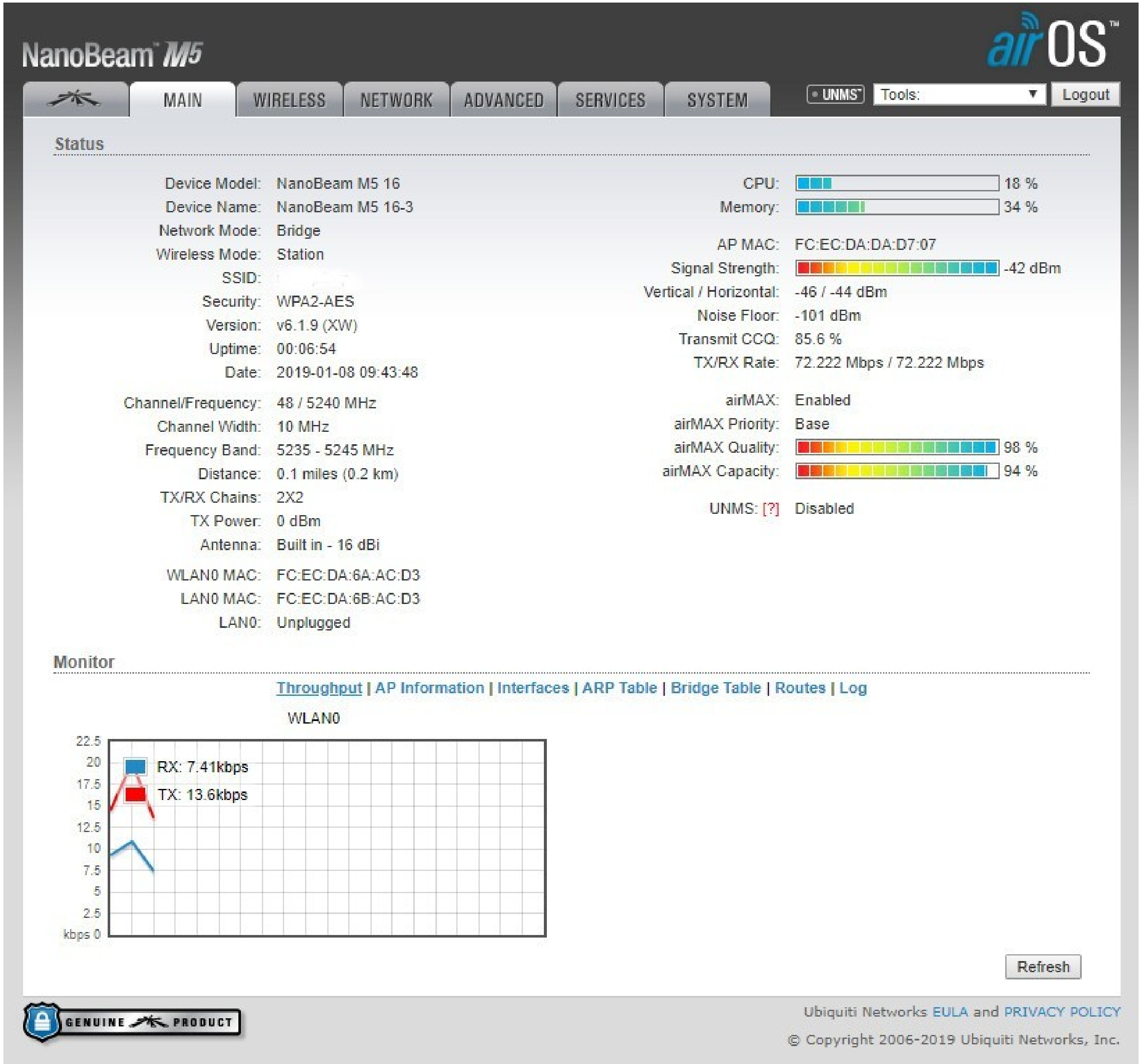
- Dither for best signal (go past peak to certain level, then go other way to same level, then go halfway back).

Setup and Programming

I’m going to start with Ubiquiti, it can be more user friendly. If all you need is a point-to-point microwave link and are not going to be linking to HamWAN, then this will work for you.

By the way, both Ubiquiti and Mikrotik will run on 12V or 24V power sources. They both come with an AC to 24VDC power adapter, and both are POE from the adapter to the dish. Cat5 is the only connection from the dish, no coax/hardline/waveguide/etc. 24 volt is recommended especially for long wire runs.

Ubiquiti AirOS



Status

Device Model: NanoBeam M5 16
Device Name: NanoBeam M5 16-3
Network Mode: Bridge
Wireless Mode: Station
SSID: [redacted]
Security: WPA2-AES
Version: v6.1.9 (XW)
Uptime: 00:06:54
Date: 2019-01-08 09:43:48

Channel/Frequency: 48 / 5240 MHz
Channel Width: 10 MHz
Frequency Band: 5235 - 5245 MHz
Distance: 0.1 miles (0.2 km)
TX/RX Chains: 2X2
TX Power: 0 dBm
Antenna: Built in - 16 dBi

WLAN0 MAC: FC:EC:DA:6A:AC:D3
LAN0 MAC: FC:EC:DA:6B:AC:D3
LAN0: Unplugged

CPU: 18 %
Memory: 34 %

AP MAC: FC:EC:DA:DA:D7:07
Signal Strength: -42 dBm
Vertical / Horizontal: -46 / -44 dBm
Noise Floor: -101 dBm
Transmit CCQ: 85.6 %
TX/RX Rate: 72.222 Mbps / 72.222 Mbps

airMAX: Enabled
airMAX Priority: Base
airMAX Quality: 98 %
airMAX Capacity: 94 %

UNMS: [?] Disabled

Monitor

RX: 7.41kbps
TX: 13.6kbps

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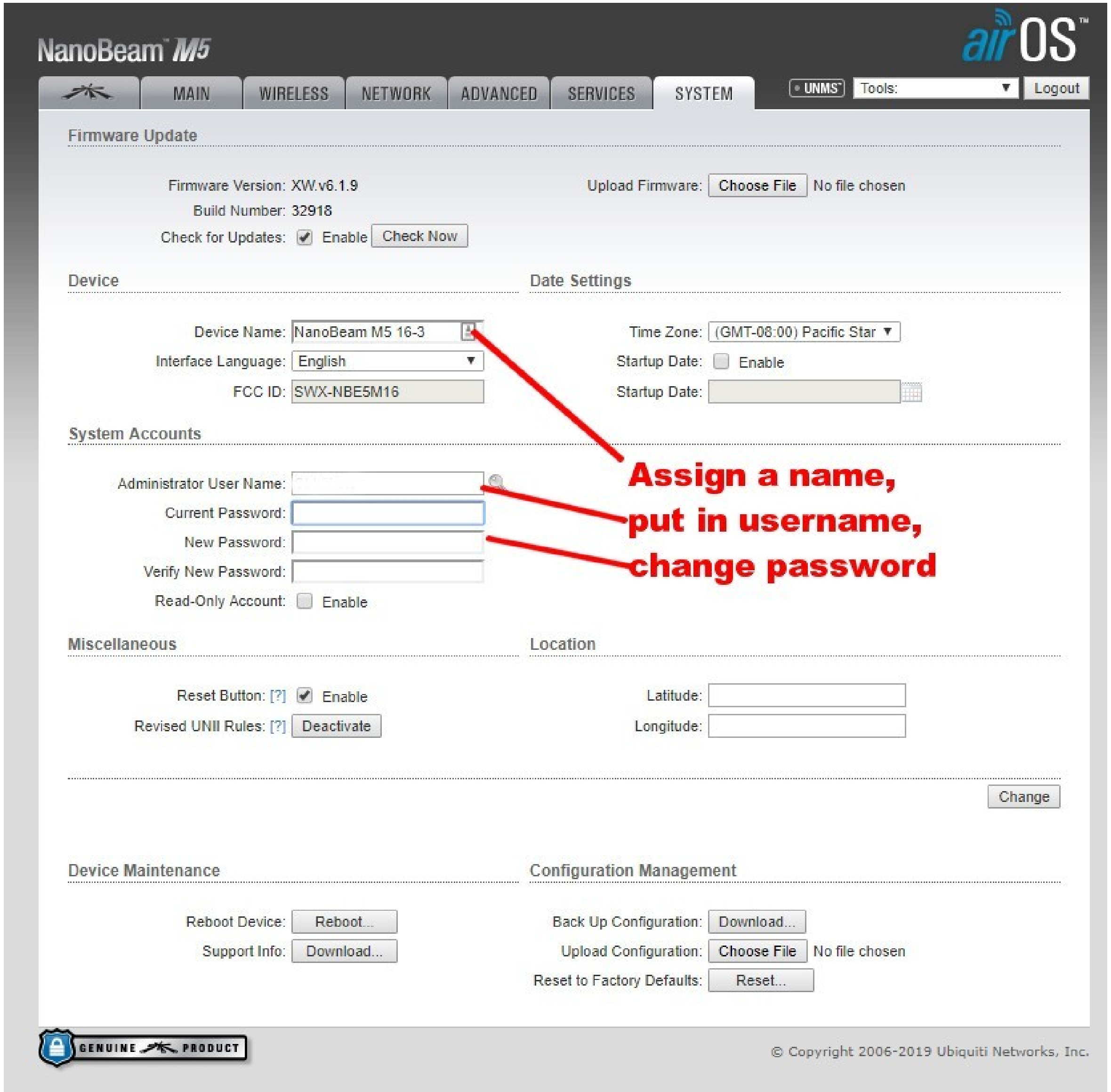
Ubiquiti AirOS



Firmware Update

Firmware Version: XW.v6.1.9

Build Number: 32918

Check for Updates: ☑ Enable [Check Now]

Upload Firmware: [Choose File] No file chosen

Device

Device Name: NanoBeam M5 16-3

Interface Language: English

FCC ID: SWX-NBE5M16

Date Settings

Time Zone: (GMT-08:00) Pacific Star

Startup Date: ☐ Enable

Startup Date:

System Accounts

Administrator User Name: [redacted]

Current Password:

New Password:

Verify New Password:

Read-Only Account: ☐ Enable

Assign a name, put in username, change password

Miscellaneous

Reset Button: [?] ☑ Enable

Revised UNII Rules: [?] [Deactivate]

Location

Latitude:

Longitude:

[Change]

Device Maintenance

Reboot Device: [Reboot...]

Support Info: [Download...]

Configuration Management

Back Up Configuration: [Download...]

Upload Configuration: [Choose File] No file chosen

Reset to Factory Defaults: [Reset...]

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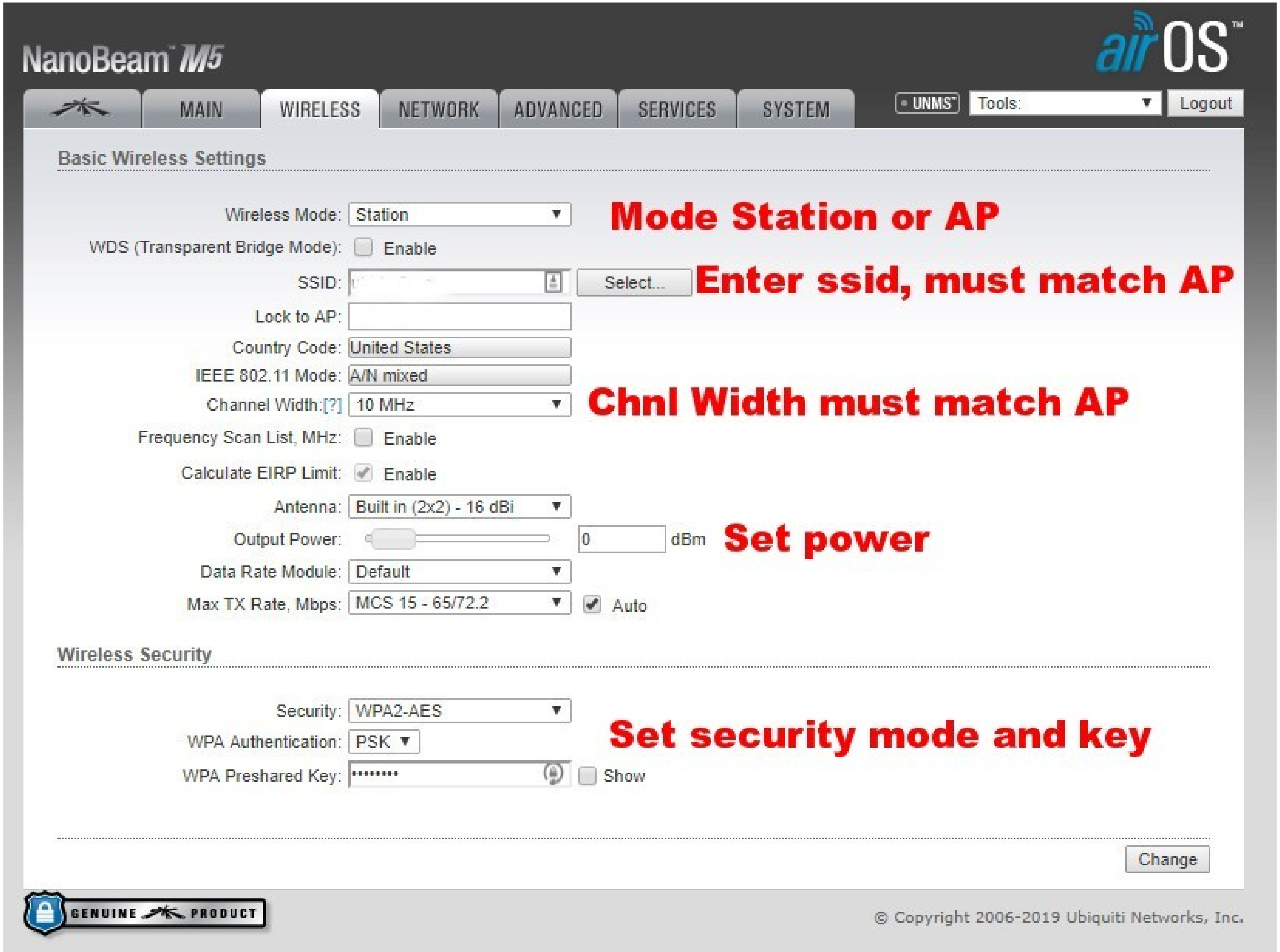
Ubiquiti AirOS



Basic Wireless Settings

Wireless Mode: Station

Mode Station or AP

WDS (Transparent Bridge Mode): ☐ Enable

SSID: [redacted] Select...

Enter ssid, must match AP

Lock to AP:

Country Code: United States

IEEE 802.11 Mode: A/N mixed

Channel Width:[?] 10 MHz

Chnl Width must match AP

Frequency Scan List, MHz: ☐ Enable

Calculate EIRP Limit: ☑ Enable

Antenna: Built in (2x2) - 16 dBi

Output Power: 0 dBm

Set power

Data Rate Module: Default

Max TX Rate, Mbps: MCS 15 - 65/72.2 ☑ Auto

Wireless Security

Security: WPA2-AES

WPA Authentication: PSK

WPA Preshared Key: •••••••• ☐ Show

Set security mode and key

Change

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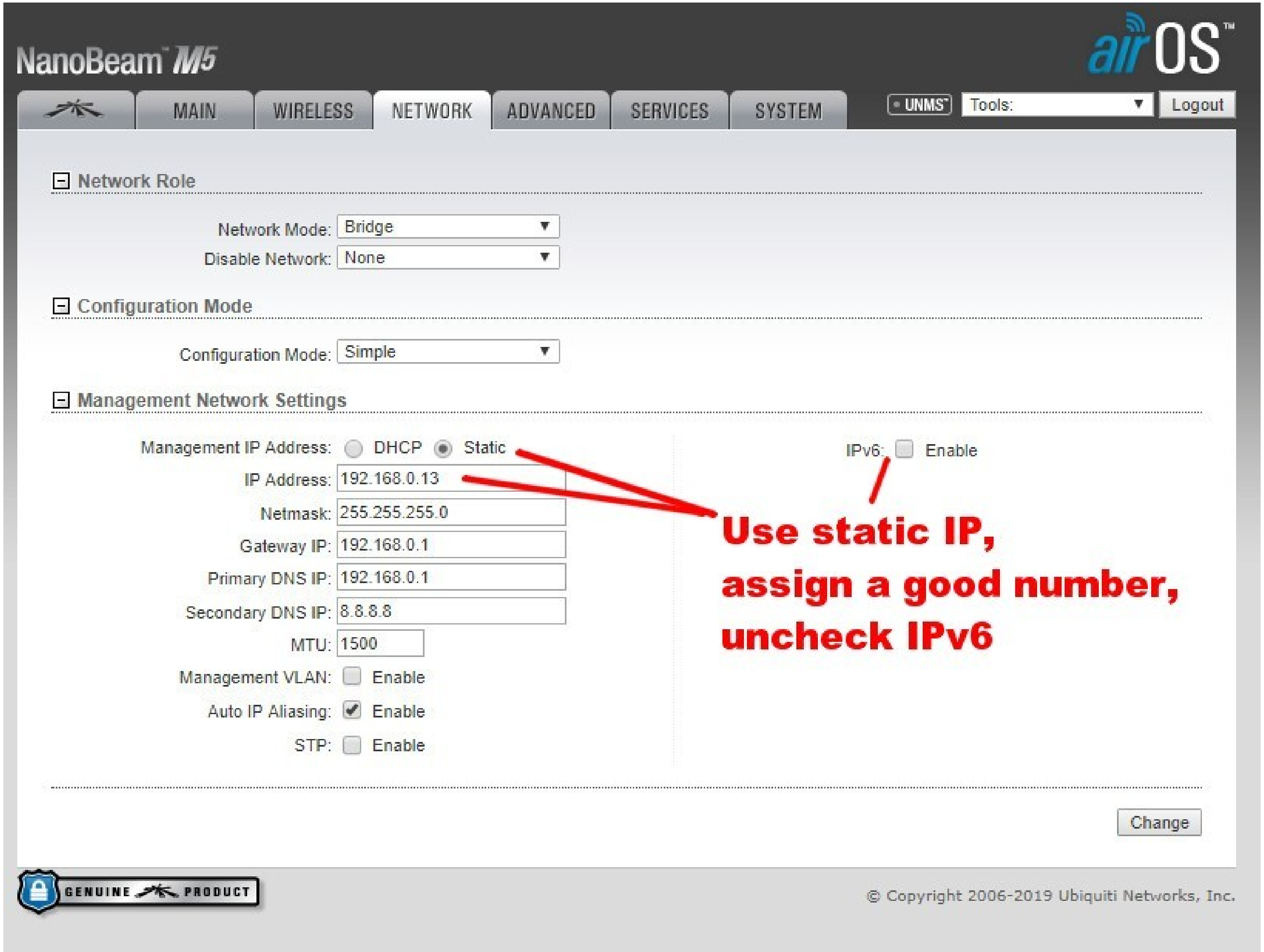
Ubiquiti AirOS



⊟ Network Role

Network Mode: Bridge ▼
Disable Network: None ▼

⊟ Configuration Mode

Configuration Mode: Simple ▼

⊟ Management Network Settings

Management IP Address: ○ DHCP ● Static
IP Address: 192.168.0.13
Netmask: 255.255.255.0
Gateway IP: 192.168.0.1
Primary DNS IP: 192.168.0.1
Secondary DNS IP: 8.8.8.8
MTU: 1500
Management VLAN: ☐ Enable
Auto IP Aliasing: ☑ Enable
STP: ☐ Enable

IPv6: ☐ Enable

Use static IP,
assign a good number,
uncheck IPv6

Change

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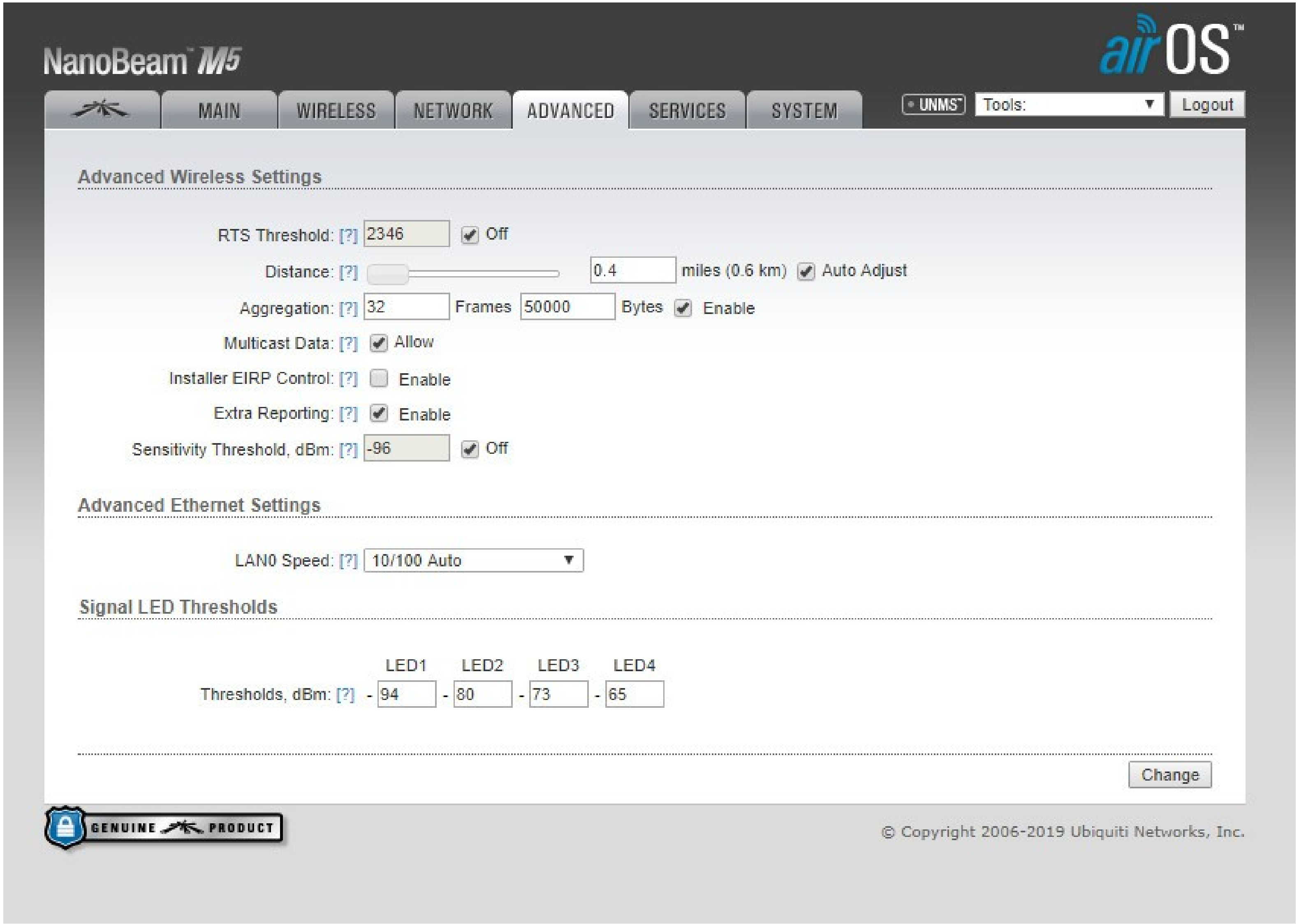
Ubiquiti AirOS



Advanced Wireless Settings

RTS Threshold: [?] 2346 ☑ Off

Distance: [?] 0.4 miles (0.6 km) ☑ Auto Adjust

Aggregation: [?] 32 Frames 50000 Bytes ☑ Enable

Multicast Data: [?] ☑ Allow

Installer EIRP Control: [?] ☐ Enable

Extra Reporting: [?] ☑ Enable

Sensitivity Threshold, dBm: [?] -96 ☑ Off

Advanced Ethernet Settings

LAN0 Speed: [?] 10/100 Auto

Signal LED Thresholds

	LED1	LED2	LED3	LED4
Thresholds, dBm: [?]	- 94	- 80	- 73	- 65

Change

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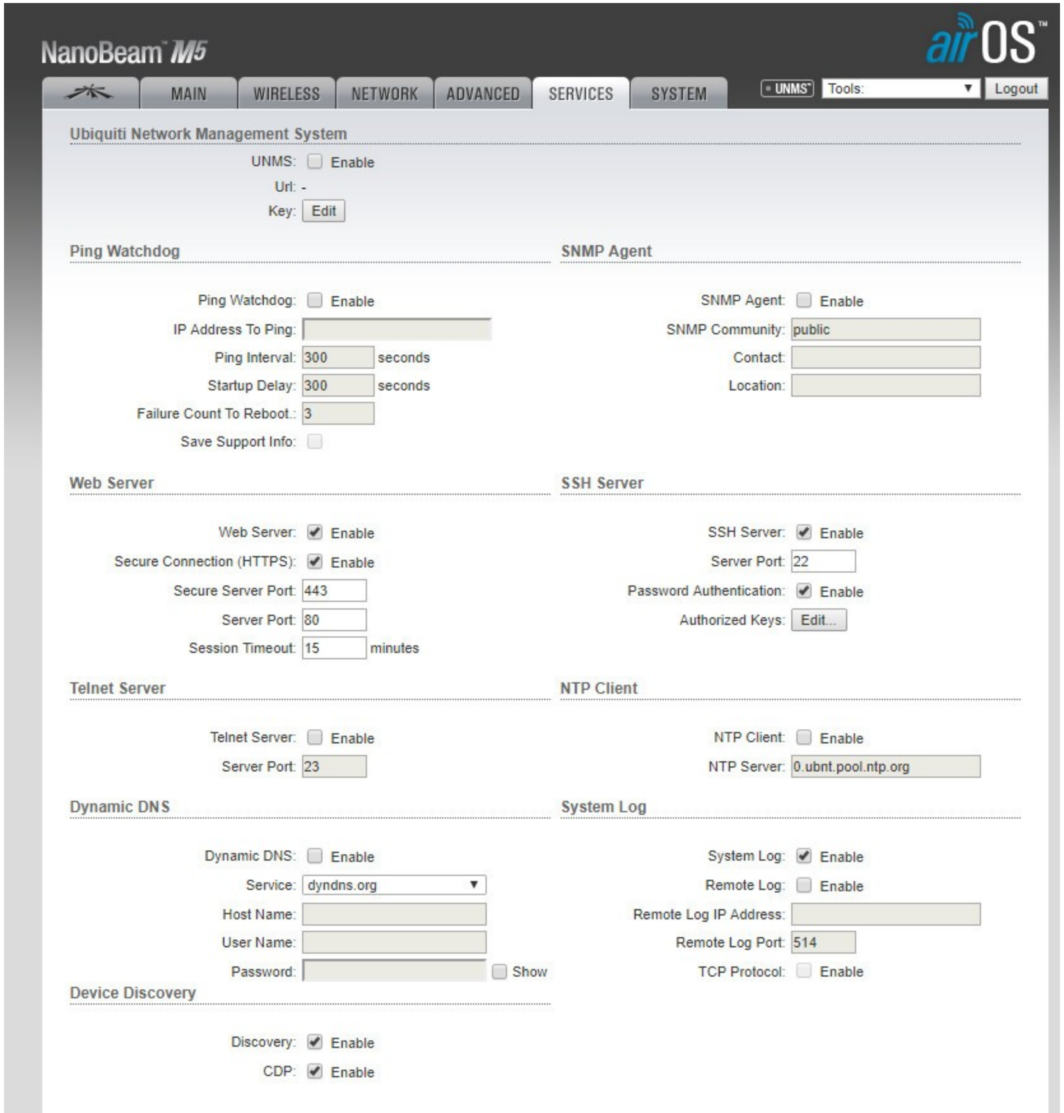
Ubiquiti AirOS



Ubiquiti Network Management System

UNMS: ☐ Enable
Url: -
Key: Edit

Ping Watchdog

Ping Watchdog: ☐ Enable
IP Address To Ping:
Ping Interval: 300 seconds
Startup Delay: 300 seconds
Failure Count To Reboot.: 3
Save Support Info: ☐

SNMP Agent

SNMP Agent: ☐ Enable
SNMP Community: public
Contact:
Location:

Web Server

Web Server: ☑ Enable
Secure Connection (HTTPS): ☑ Enable
Secure Server Port: 443
Server Port: 80
Session Timeout: 15 minutes

SSH Server

SSH Server: ☑ Enable
Server Port: 22
Password Authentication: ☑ Enable
Authorized Keys: Edit...

Telnet Server

Telnet Server: ☐ Enable
Server Port: 23

NTP Client

NTP Client: ☐ Enable
NTP Server: 0.ubnt.pool.ntp.org

Dynamic DNS

Dynamic DNS: ☐ Enable
Service: dyndns.org
Host Name:
User Name:
Password: ☐ Show

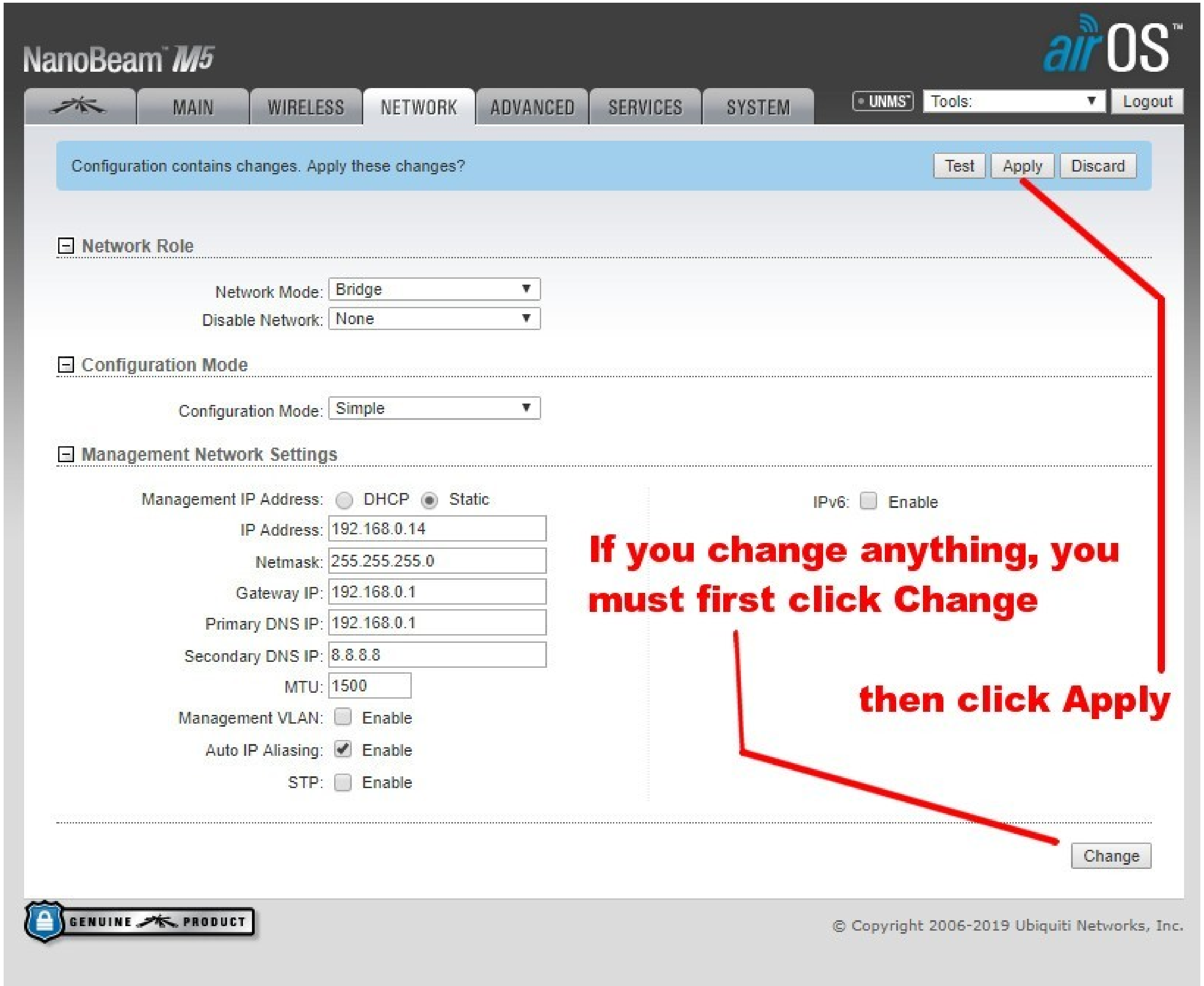
System Log

System Log: ☑ Enable
Remote Log: ☐ Enable
Remote Log IP Address:
Remote Log Port: 514
TCP Protocol: ☐ Enable

Device Discovery

Discovery: ☑ Enable
CDP: ☑ Enable

Ubiquiti AirOS



Configuration contains changes. Apply these changes?

Network Role

Network Mode: Bridge

Disable Network: None

Configuration Mode

Configuration Mode: Simple

Management Network Settings

Management IP Address: ○ DHCP ● Static

IPv6: ☐ Enable

IP Address: 192.168.0.14

Netmask: 255.255.255.0

Gateway IP: 192.168.0.1

Primary DNS IP: 192.168.0.1

Secondary DNS IP: 8.8.8.8

MTU: 1500

Management VLAN: ☐ Enable

Auto IP Aliasing: ☑ Enable

STP: ☐ Enable

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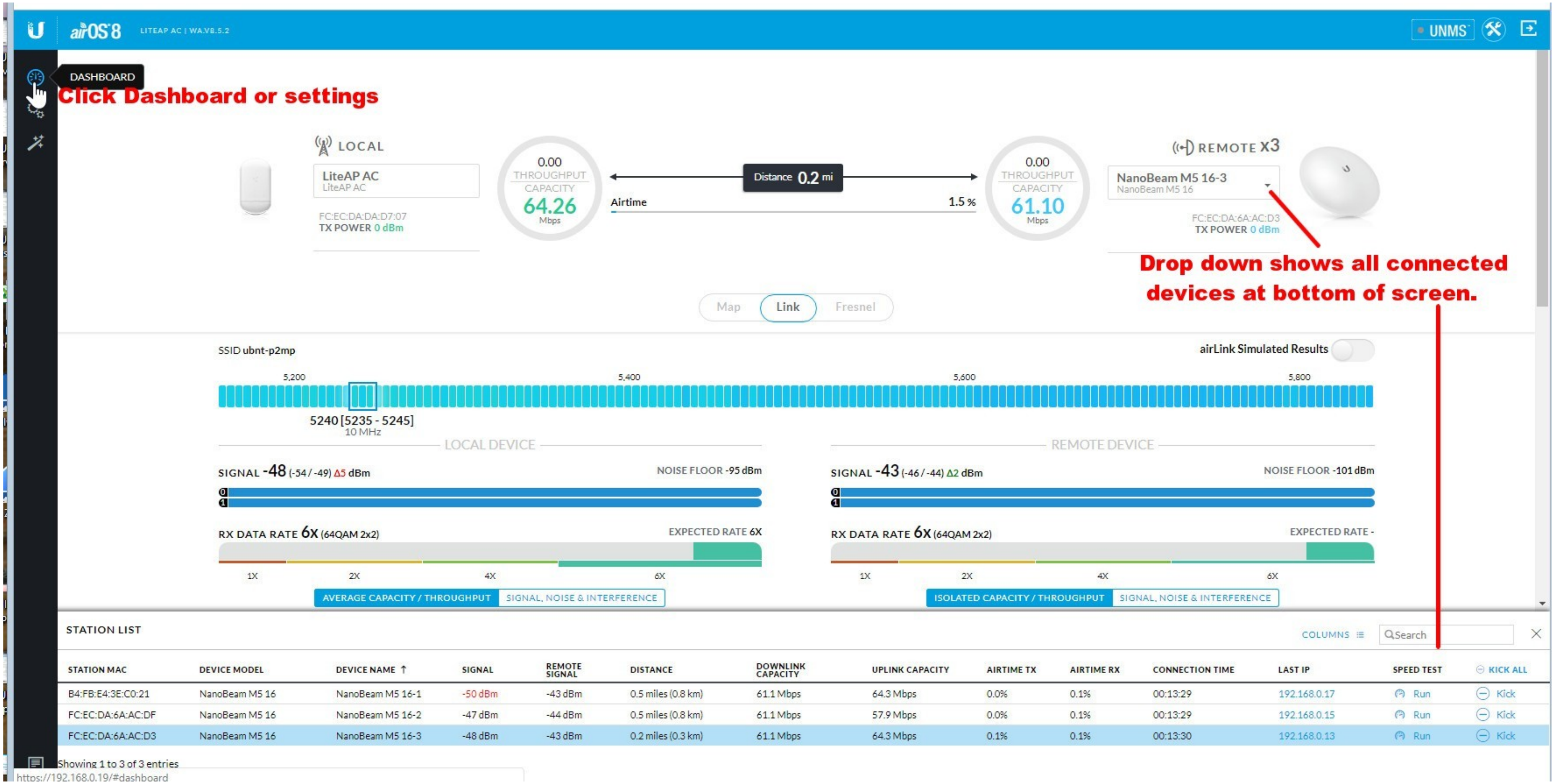
If you change anything, you must first click Change

then click Apply

Ubiquiti LightBeam



Click Dashboard or settings

LiteAP AC
LiteAP AC
FC:EC:DA:DA:D7:07
TX POWER 0 dBm

0.00 THROUGHPUT
CAPACITY 64.26 Mbps

Distance 0.2 mi
Airtime 1.5 %

0.00 THROUGHPUT
CAPACITY 61.10 Mbps

NanoBeam M5 16-3
NanoBeam M5 16
FC:EC:DA:6A:AC:D3
TX POWER 0 dBm

Drop down shows all connected devices at bottom of screen.

SSID ubnt-p2mp

airLink Simulated Results

5240 [5235 - 5245]
10 MHz

LOCAL DEVICE
SIGNAL -48 (-54 / -49) Δ5 dBm
NOISE FLOOR -95 dBm
RX DATA RATE 6X (64QAM 2x2)
EXPECTED RATE 6X

REMOTE DEVICE
SIGNAL -43 (-46 / -44) Δ2 dBm
NOISE FLOOR -101 dBm
RX DATA RATE 6X (64QAM 2x2)
EXPECTED RATE -

STATION LIST

STATION MAC	DEVICE MODEL	DEVICE NAME ↑	SIGNAL	REMOTE SIGNAL	DISTANCE	DOWNLINK CAPACITY	UPLINK CAPACITY	AIRTIME TX	AIRTIME RX	CONNECTION TIME	LAST IP	SPEED TEST	KICK ALL
B4:FB:E4:3E:C0:21	NanoBeam M5 16	NanoBeam M5 16-1	-50 dBm	-43 dBm	0.5 miles (0.8 km)	61.1 Mbps	64.3 Mbps	0.0%	0.1%	00:13:29	192.168.0.17	Run	Kick
FC:EC:DA:6A:AC:DF	NanoBeam M5 16	NanoBeam M5 16-2	-47 dBm	-44 dBm	0.5 miles (0.8 km)	61.1 Mbps	57.9 Mbps	0.0%	0.1%	00:13:29	192.168.0.15	Run	Kick
FC:EC:DA:6A:AC:D3	NanoBeam M5 16	NanoBeam M5 16-3	-48 dBm	-43 dBm	0.2 miles (0.3 km)	61.1 Mbps	64.3 Mbps	0.1%	0.1%	00:13:30	192.168.0.13	Run	Kick

Showing 1 to 3 of 3 entries

https://192.168.0.19/#dashboard

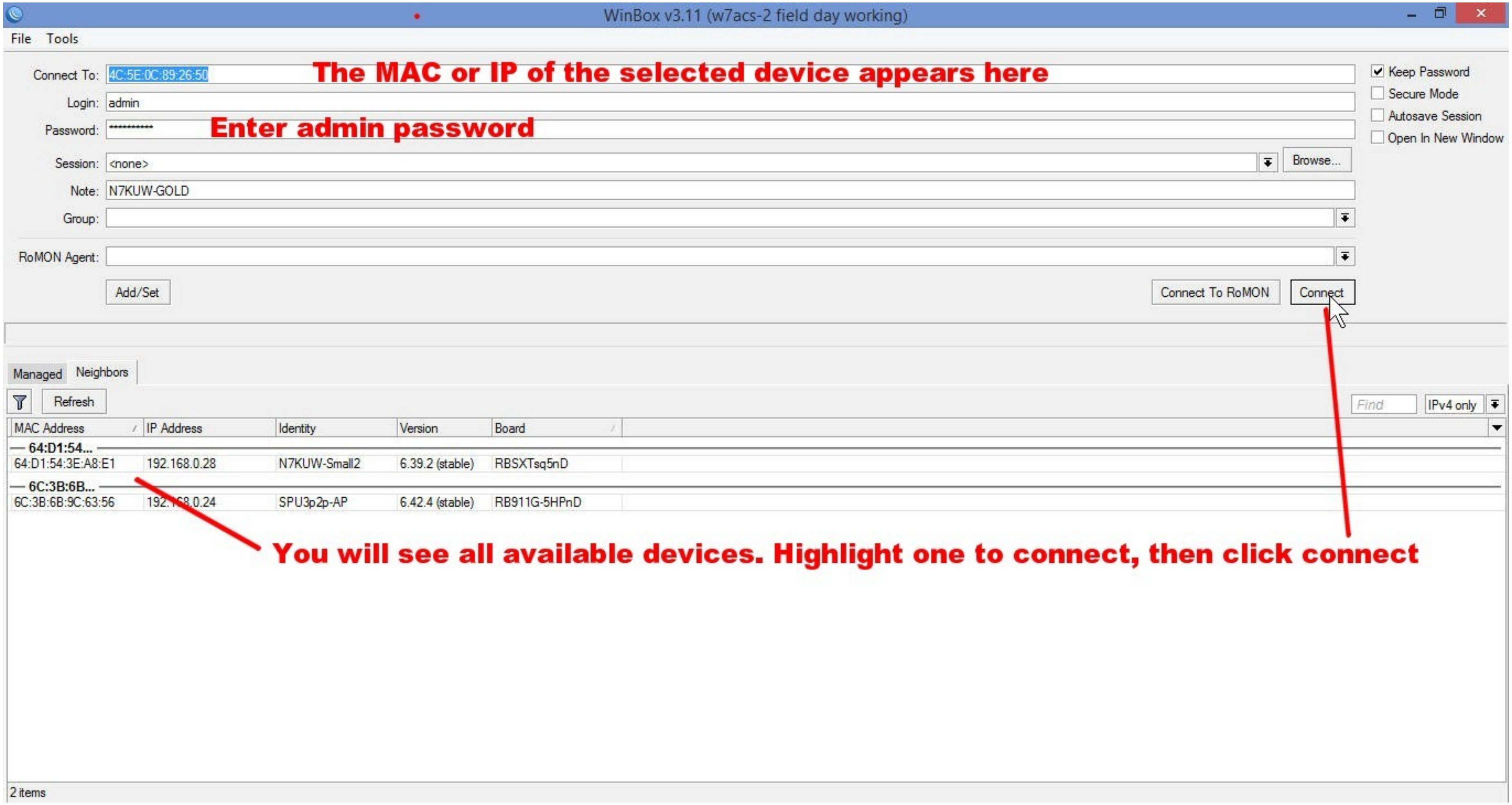
Mikrotik

- Mikrotik can be done a number of different ways, but the “easiest” is using a utility called Winbox, which you can download from Mikrotik.

- There are a bunch of tabs down the left side of the Winbox application, which take you to all kinds of stuff. There are also, typically, multiple ways to do the same thing.

- One tab is “Terminal”, which lets you do all the programming via command-line entries. This is how the information for setting up a HamWAN client is provided, and you need to be careful with your entries.

MikroTik Winbox



Connect To: 4C:5E:0C:89:26:50

Login: admin

Password: ***********

Session: <none>

Note: N7KUW-GOLD

Group:

RoMON Agent:

☑ Keep Password
☐ Secure Mode
☐ Autosave Session
☐ Open In New Window

IPv4 only

MAC Address	IP Address	Identity	Version	Board
64:D1:54...				
64:D1:54:3E:A8:E1	192.168.0.28	N7KUW-Small2	6.39.2 (stable)	RBSXTsq5nD
6C:3B:6B...				
6C:3B:6B:9C:63:56	192.168.0.24	SPU3p2p-AP	6.42.4 (stable)	RB911G-5HPnD

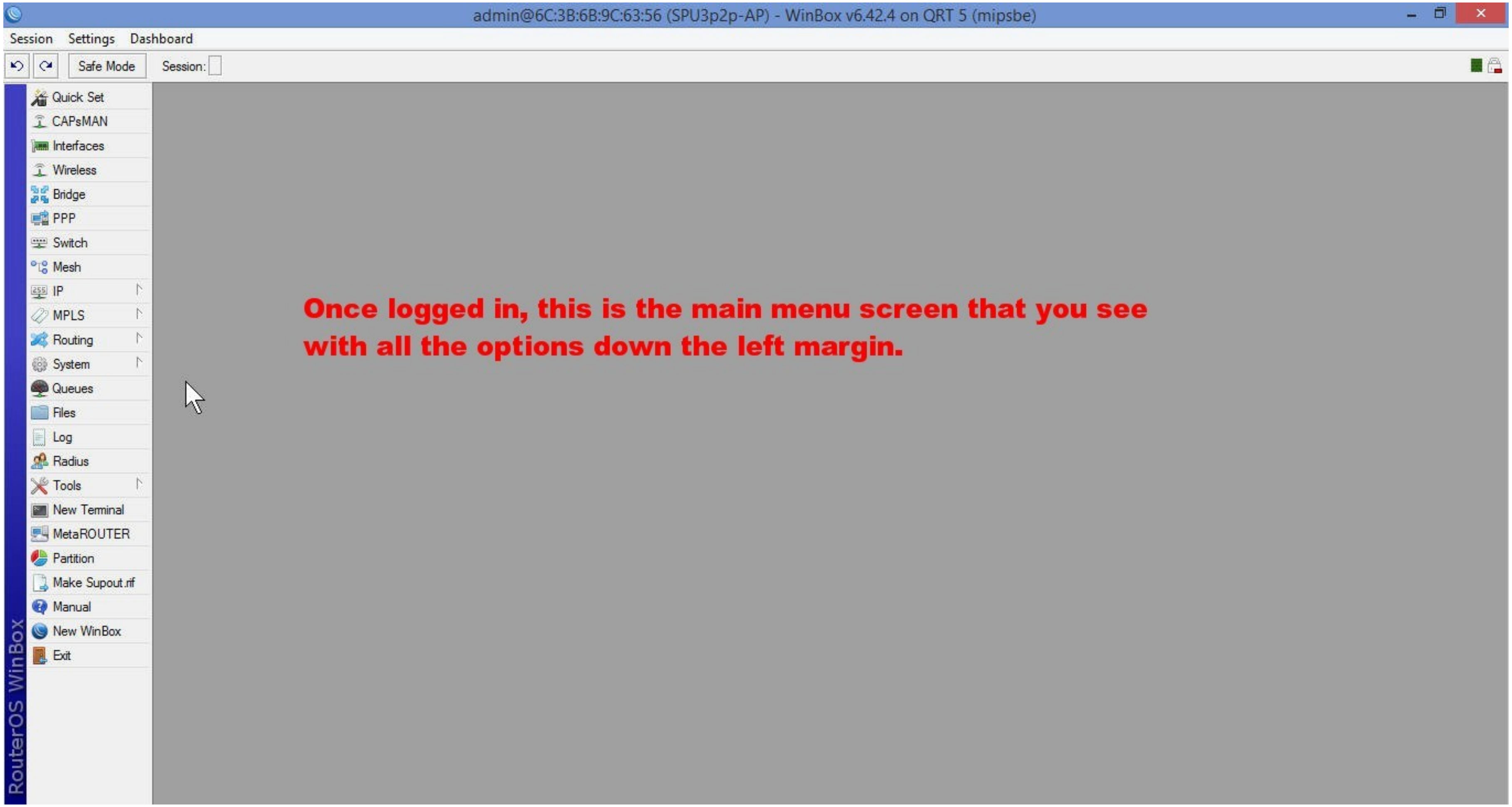
2 items

The MAC or IP of the selected device appears here

Enter admin password

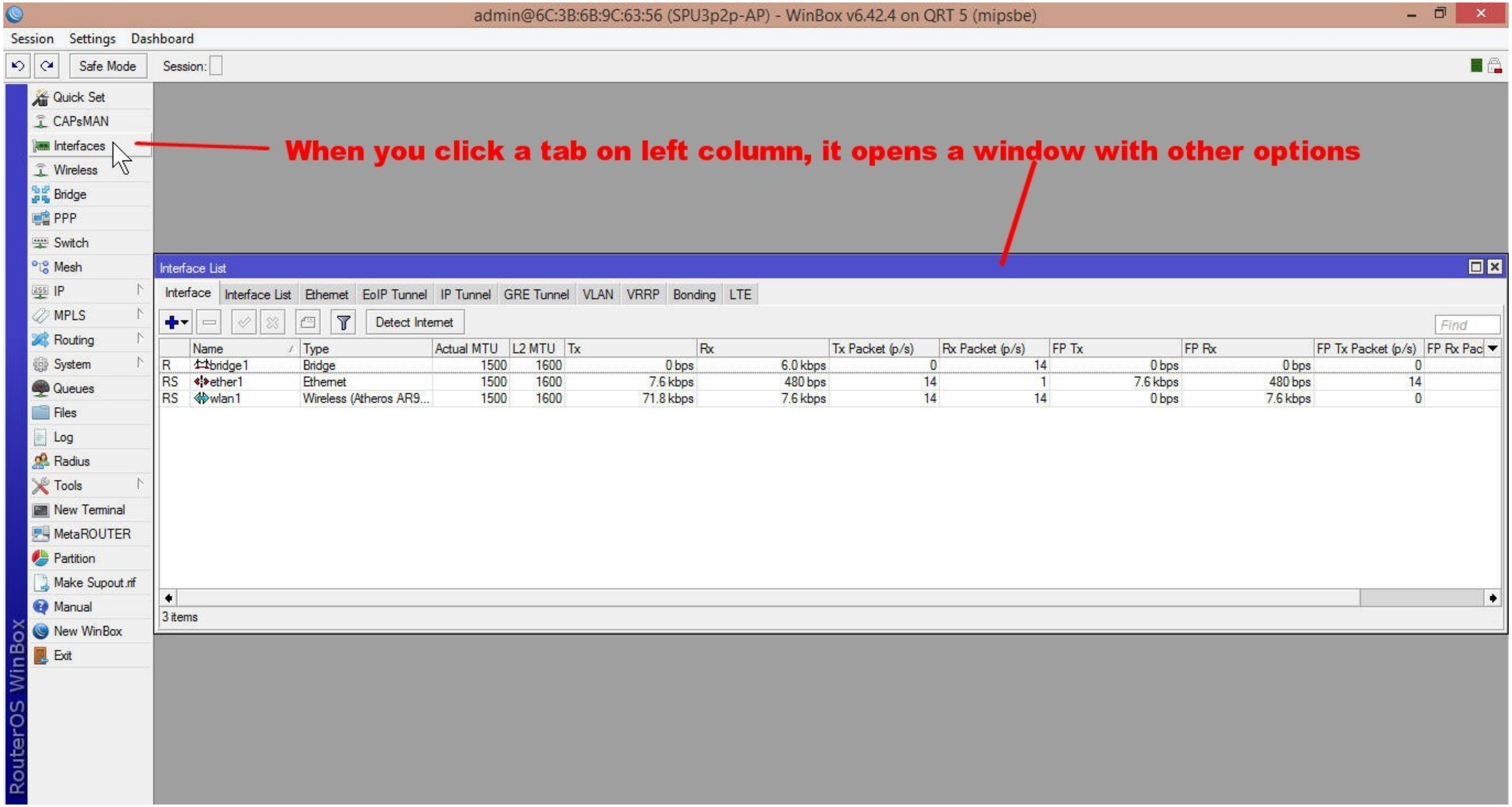
You will see all available devices. Highlight one to connect, then click connect

MikroTik Winbox



Once logged in, this is the main menu screen that you see with all the options down the left margin.

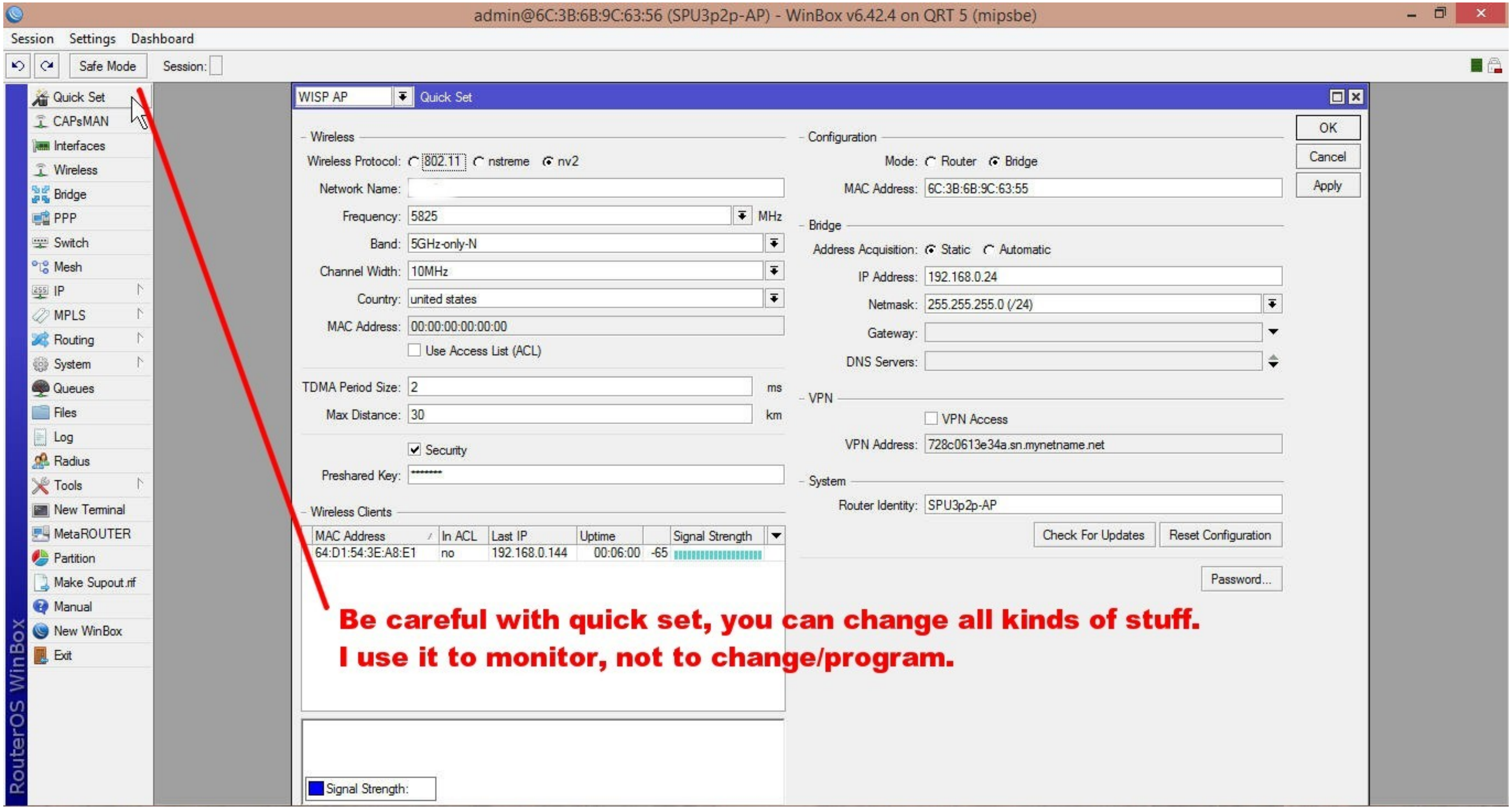
MikroTik Winbox



When you click a tab on left column, it opens a window with other options

	Name	Type	Actual MTU	L2 MTU	Tx	Rx	Tx Packet (p/s)	Rx Packet (p/s)	FP Tx	FP Rx	FP Tx Packet (p/s)	FP Rx Pac
R	bridge1	Bridge	1500	1600	0 bps	6.0 kbps	0	14	0 bps	0 bps	0	
RS	ether1	Ethernet	1500	1600	7.6 kbps	480 bps	14	1	7.6 kbps	480 bps	14	
RS	wlan1	Wireless (Atheros AR9...	1500	1600	71.8 kbps	7.6 kbps	14	14	0 bps	7.6 kbps	0	

MikroTik Winbox



admin@6C:3B:6B:9C:63:56 (SPU3p2p-AP) - WinBox v6.42.4 on QRT 5 (mipsbe)

WISP AP — Quick Set

Wireless

Wireless Protocol: ○ 802.11 ○ nstreme ● nv2
Network Name:
Frequency: 5825 MHz
Band: 5GHz-only-N
Channel Width: 10MHz
Country: united states
MAC Address: 00:00:00:00:00:00
☐ Use Access List (ACL)
TDMA Period Size: 2 ms
Max Distance: 30 km
☑ Security
Preshared Key: ********

Wireless Clients

MAC Address	In ACL	Last IP	Uptime	Signal Strength
64:D1:54:3E:A8:E1	no	192.168.0.144	00:06:00	-65

🟦 Signal Strength:

Configuration

Mode: ○ Router ● Bridge
MAC Address: 6C:3B:6B:9C:63:55

Bridge

Address Acquisition: ● Static ○ Automatic
IP Address: 192.168.0.24
Netmask: 255.255.255.0 (/24)
Gateway:
DNS Servers:

VPN

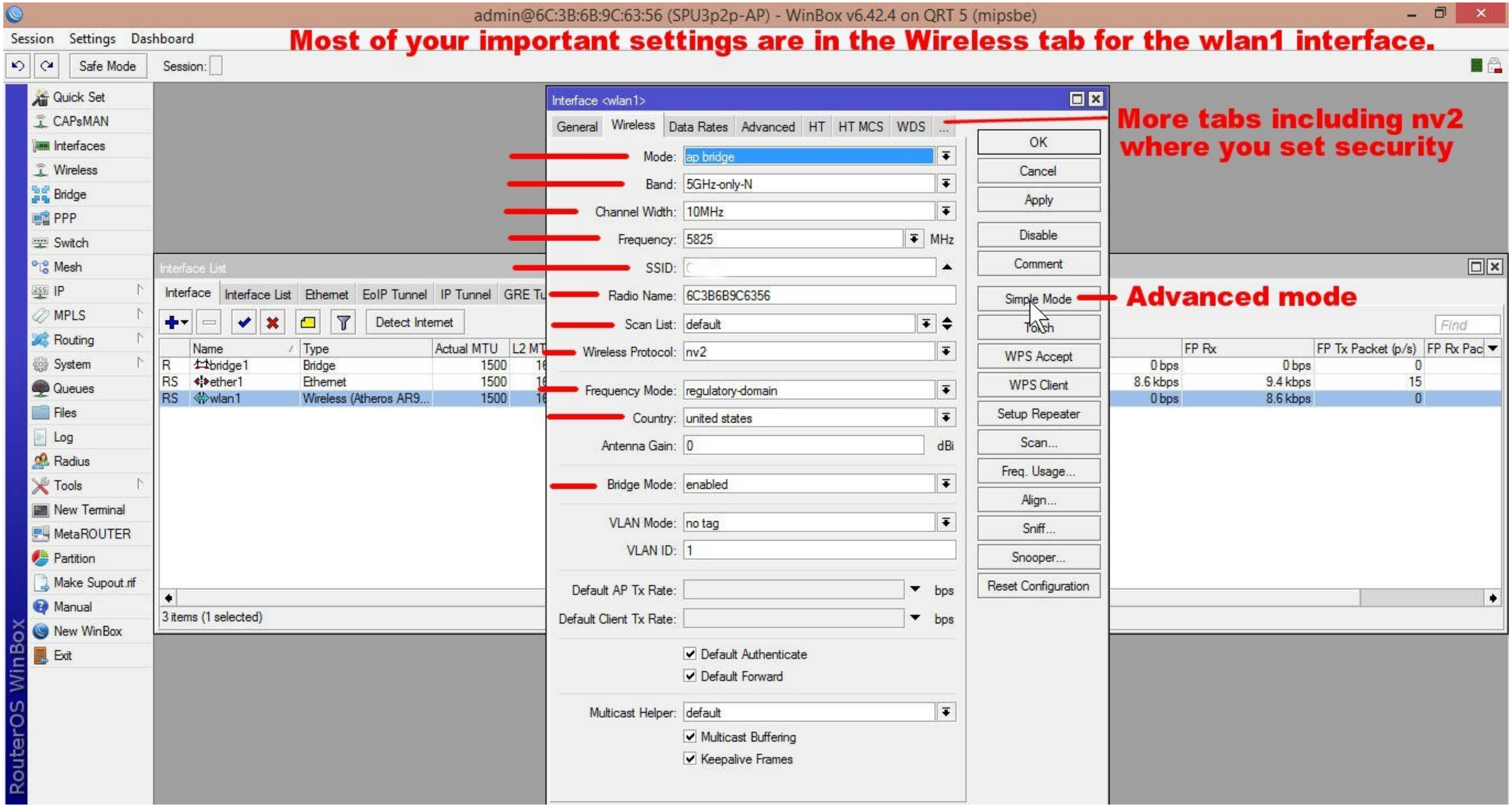
☐ VPN Access
VPN Address: 728c0613e34a.sn.mynetname.net

System

Router Identity: SPU3p2p-AP

Be careful with quick set, you can change all kinds of stuff.
I use it to monitor, not to change/program.

MikroTik Winbox



admin@6C:3B:6B:9C:63:56 (SPU3p2p-AP) - WinBox v6.42.4 on QRT 5 (mipsbe)

Most of your important settings are in the Wireless tab for the wlan1 interface.

More tabs including nv2 where you set security

Advanced mode

Interface <wlan1>

- Mode: ap bridge
- Band: 5GHz-only-N
- Channel Width: 10MHz
- Frequency: 5825 MHz
- SSID: [redacted]
- Radio Name: 6C3B6B9C6356
- Scan List: default
- Wireless Protocol: nv2
- Frequency Mode: regulatory-domain
- Country: united states
- Antenna Gain: 0 dBi
- Bridge Mode: enabled
- VLAN Mode: no tag
- VLAN ID: 1
- Default AP Tx Rate: bps
- Default Client Tx Rate: bps
- ☑ Default Authenticate
- ☑ Default Forward
- Multicast Helper: default
- ☑ Multicast Buffering
- ☑ Keepalive Frames

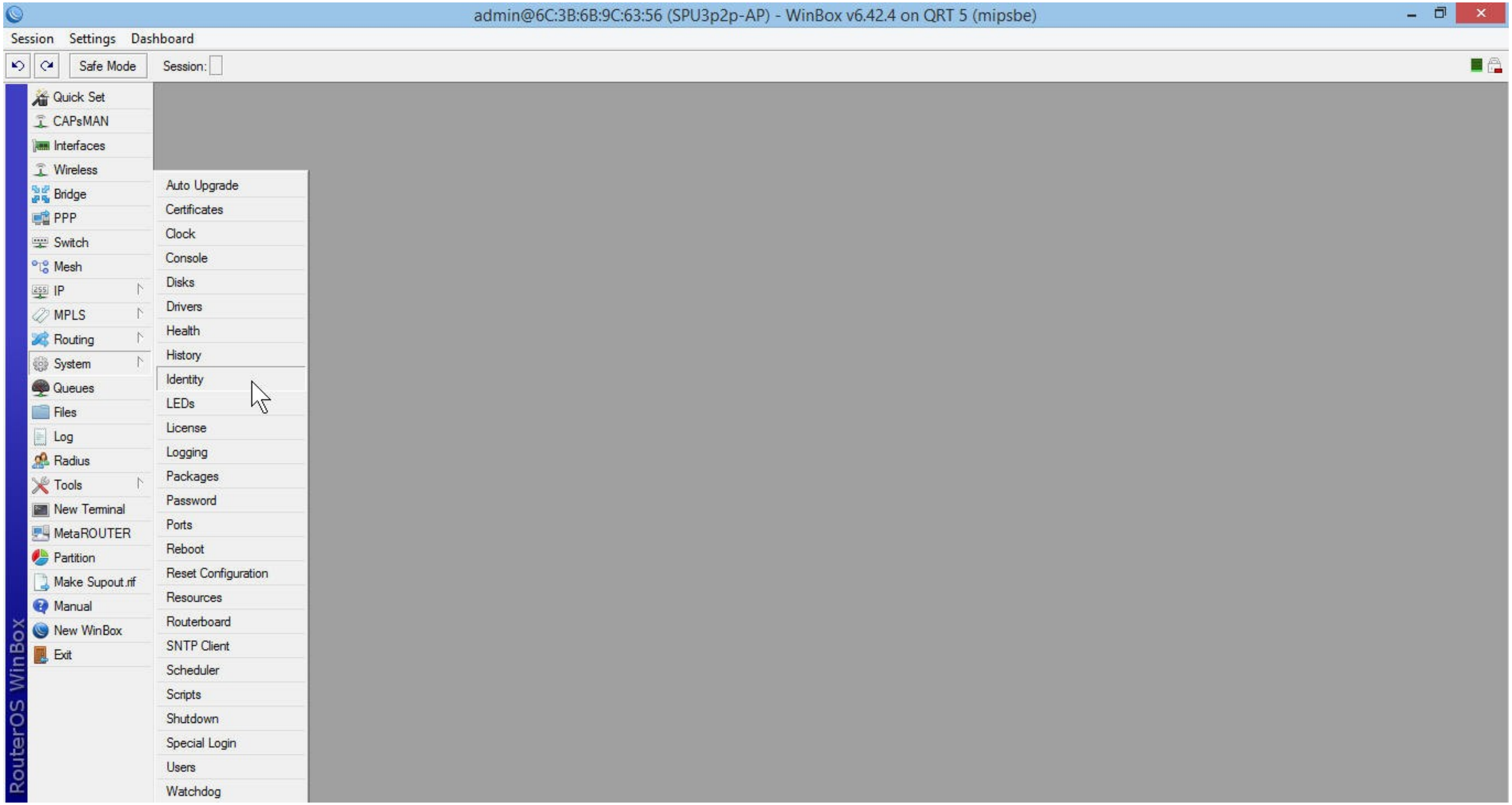
Interface List

	Name	Type	Actual MTU
R	bridge1	Bridge	1500
RS	ether1	Ethernet	1500
RS	wlan1	Wireless (Atheros AR9...	1500

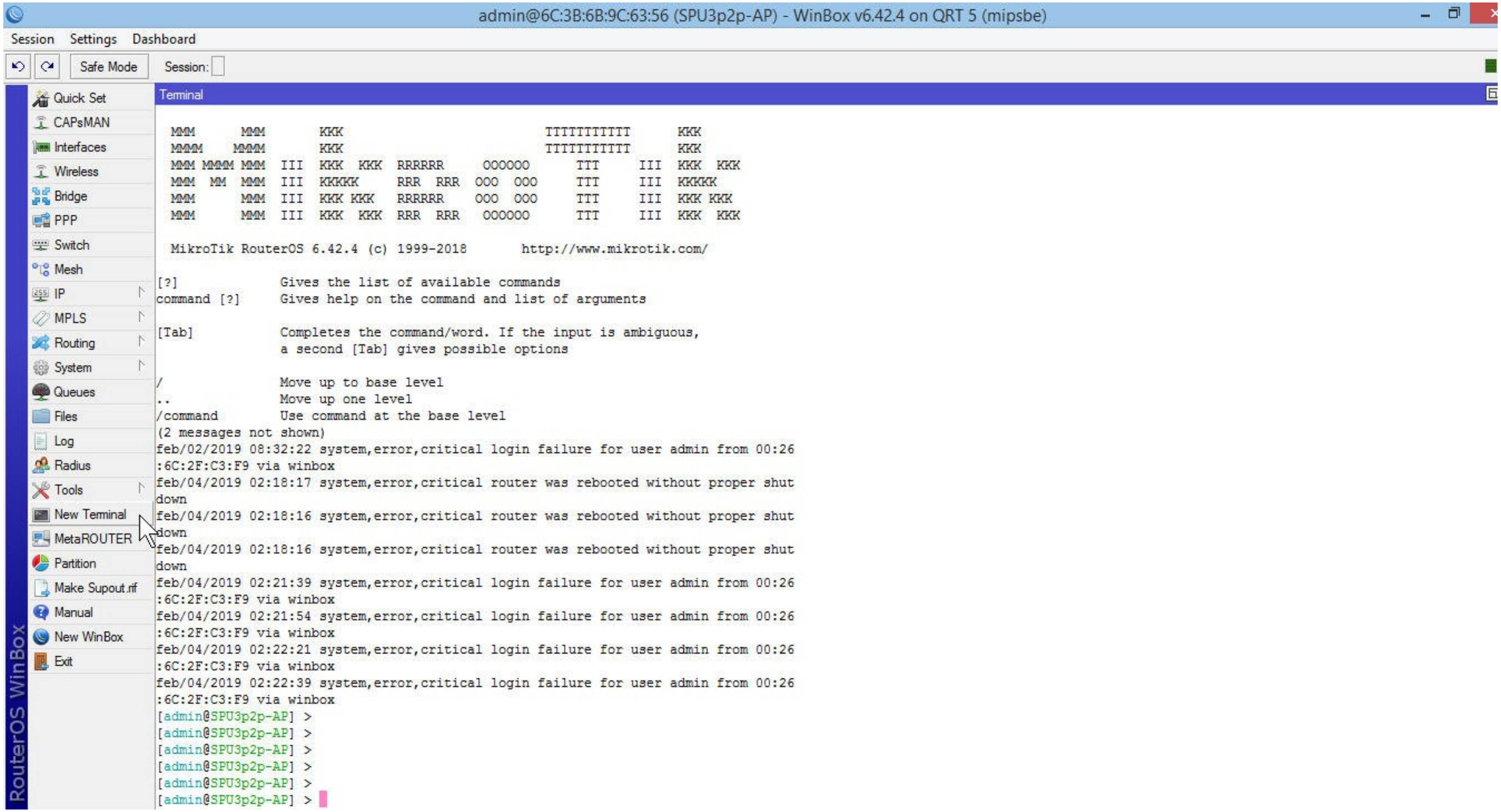
	FP Rx	FP Tx Packet (p/s)	FP Rx Pac
0 bps	0 bps	0	
8.6 kbps	9.4 kbps	15	
0 bps	8.6 kbps	0	

3 items (1 selected)

MikroTik Winbox



MikroTik Winbox



```
  MMM      MMM       KKK                          TTTTTTTTTTT      KKK
  MMMM    MMMM       KKK                          TTTTTTTTTTT      KKK
  MMM MMMM MMM  III  KKK  KKK  RRRRRR     OOOOOO      TTT     III  KKK  KKK
  MMM  MM  MMM  III  KKKKK     RRR  RRR  OOO  OOO     TTT     III  KKKKK
  MMM      MMM  III  KKK KKK   RRRRRR    OOO  OOO     TTT     III  KKK KKK
  MMM      MMM  III  KKK  KKK  RRR  RRR   OOOOOO      TTT     III  KKK  KKK

  MikroTik RouterOS 6.42.4 (c) 1999-2018       http://www.mikrotik.com/

[?]             Gives the list of available commands
command [?]     Gives help on the command and list of arguments

[Tab]           Completes the command/word. If the input is ambiguous,
                a second [Tab] gives possible options

/               Move up to base level
..              Move up one level
/command        Use command at the base level
(2 messages not shown)
feb/02/2019 08:32:22 system,error,critical login failure for user admin from 00:26
:6C:2F:C3:F9 via winbox
feb/04/2019 02:18:17 system,error,critical router was rebooted without proper shut
down
feb/04/2019 02:18:16 system,error,critical router was rebooted without proper shut
down
feb/04/2019 02:18:16 system,error,critical router was rebooted without proper shut
down
feb/04/2019 02:21:39 system,error,critical login failure for user admin from 00:26
:6C:2F:C3:F9 via winbox
feb/04/2019 02:21:54 system,error,critical login failure for user admin from 00:26
:6C:2F:C3:F9 via winbox
feb/04/2019 02:22:21 system,error,critical login failure for user admin from 00:26
:6C:2F:C3:F9 via winbox
feb/04/2019 02:22:39 system,error,critical login failure for user admin from 00:26
:6C:2F:C3:F9 via winbox
[admin@SPU3p2p-AP] >
[admin@SPU3p2p-AP] >
[admin@SPU3p2p-AP] >
[admin@SPU3p2p-AP] >
[admin@SPU3p2p-AP] >
[admin@SPU3p2p-AP] >
```

MikroTik Winbox

To set up a simple point-to-point system with no bells and whistles, the following link covers the minimum steps and process in as simple a way as possible. I'll add a few comments/suggestions below. You can do a point-to-point or a point-to-multipoint using these instructions (depending on class of software license from Mikrotik – level 4 needed for multipoint).

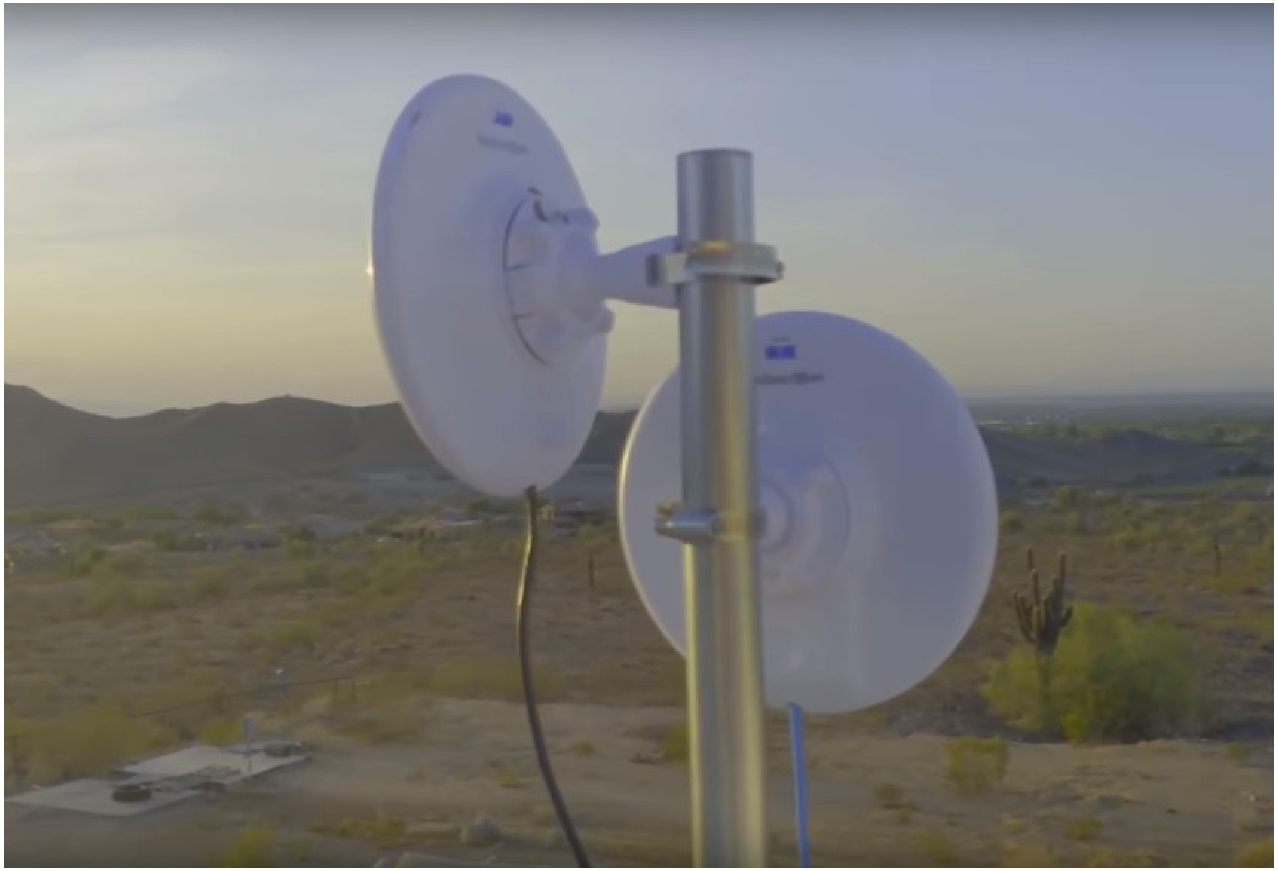
https://blog.linitx.com/howto-building-building-ptp-links-mikrotik-wireless-products/

My comments.

1. If you are going to use Part 15 WiFi frequencies, then set the frequency mode to Regulatory Domain, and set the Country to United States. You can't set it up in a non-compliant manner. If you want to use amateur radio frequencies, then set the frequency mode to Superchannel (only available on non-US models) and set the Country to no-country-set.

Multiple Hops

In general, multiple hops work. Keep frequencies as far separated as possible and try separating and/or shielding antennas at the relay point.



Mixing Systems

In general, mixing systems may not work. You are best off using equipment from the same manufacturer for all parts of your system.

I had problems mixing Ubiquiti and Mikrotik in a multiple-hop set of links. Partially resolved by using a different Ubiquiti AP. Something to do with properly passing Layer 2 MAC address.

Limits of my testing

The only thing I tested was a Layer 2 point-to-point relay where there was some sort of internet connection as the “source”, and a laptop trying to connect to the internet as the “destination”. DHCP was done through the link(s), with the laptop pulling it’s IP address from the source. Testing was done by pinging 8.8.8.8 as well as connecting to an assortment of web pages successfully (that were not cached), including speed tests.

Data speed

I only tested to the limits of my home internet connection, which is 30 mbps down and 10 up.

With HamWAN as my “source”, I was typically limited to somewhere around 4 mpbs down and 2 up.

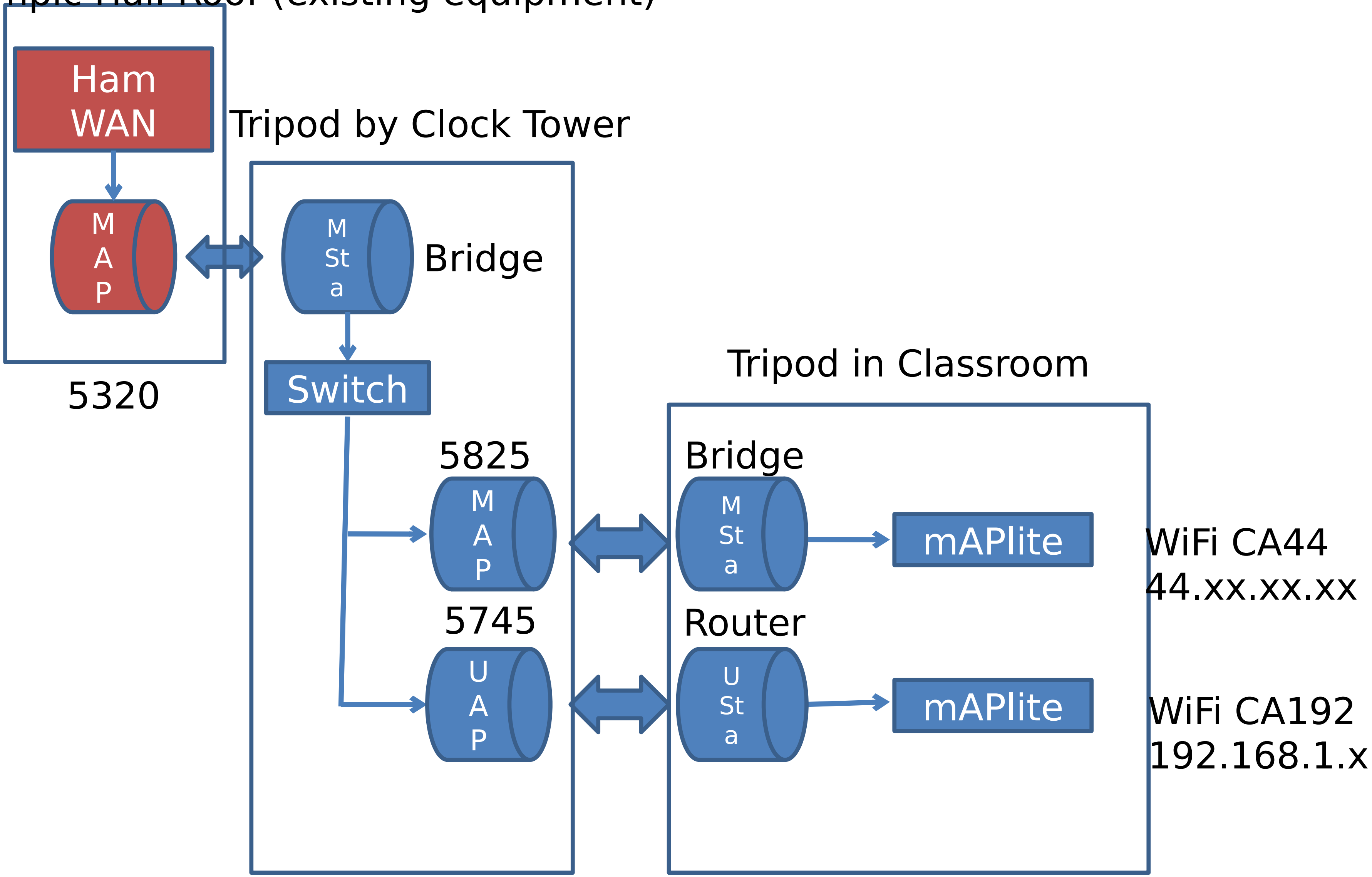
If your speed requirements are high, there are equipment and configuration choices that can enhance your throughput.

Today’s Demo System

Building Penetration

Some Neighborhood Testing

ympic Hall Roof (existing equipment)



Ham WAN

MAP

5320

Tripod by Clock Tower

MSta

Bridge

Switch

5825

MAP

5745

UAP

Tripod in Classroom

Bridge

MSta

mAPlite

Router

USta

mAPlite

WiFi CA44
44.xx.xx.xx

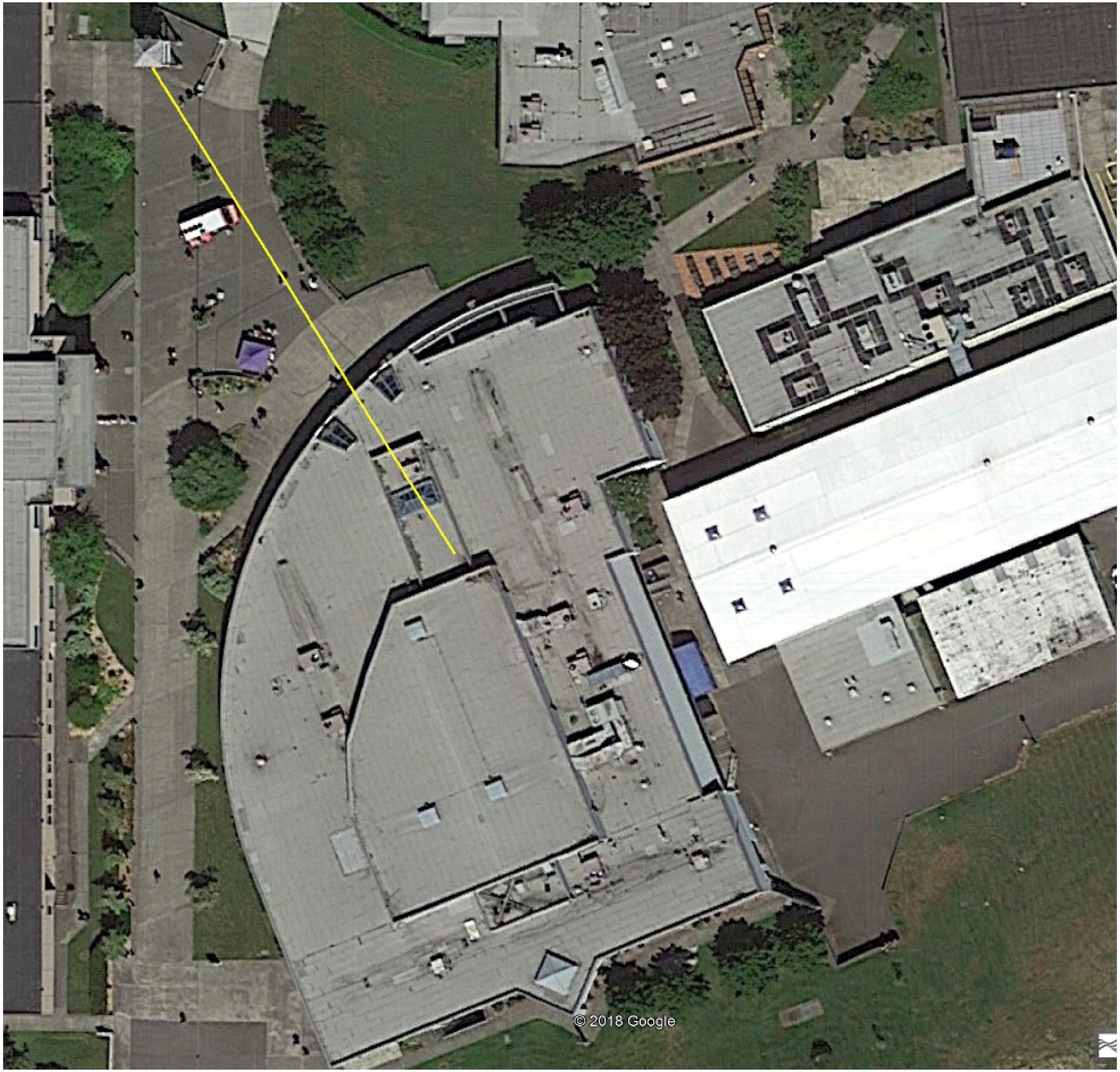
WiFi CA192
192.168.1.x

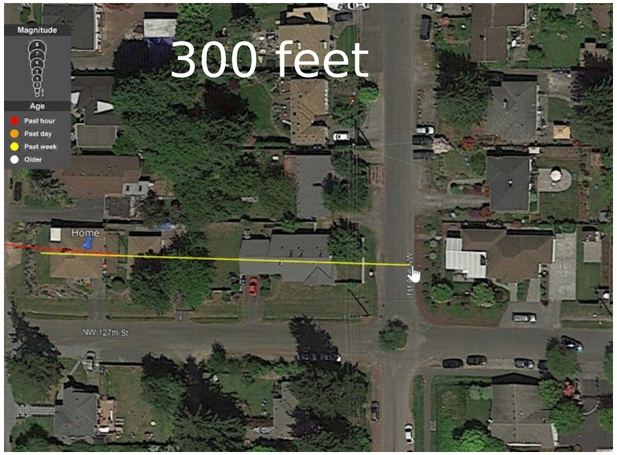
Wifi Password: CommAcad2019

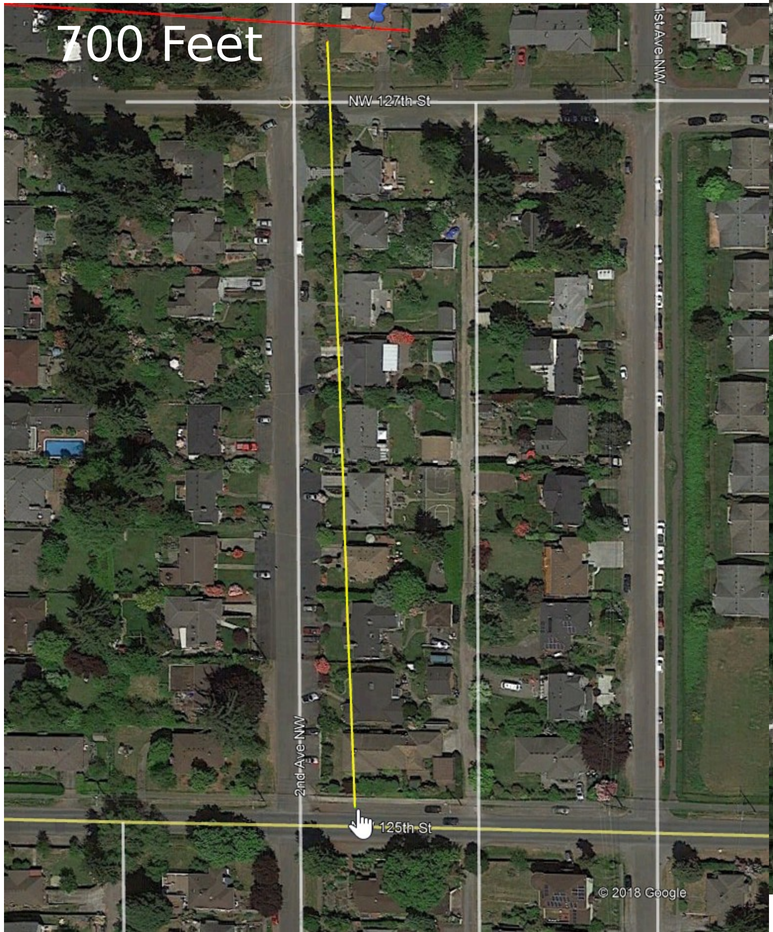
Building Penetration

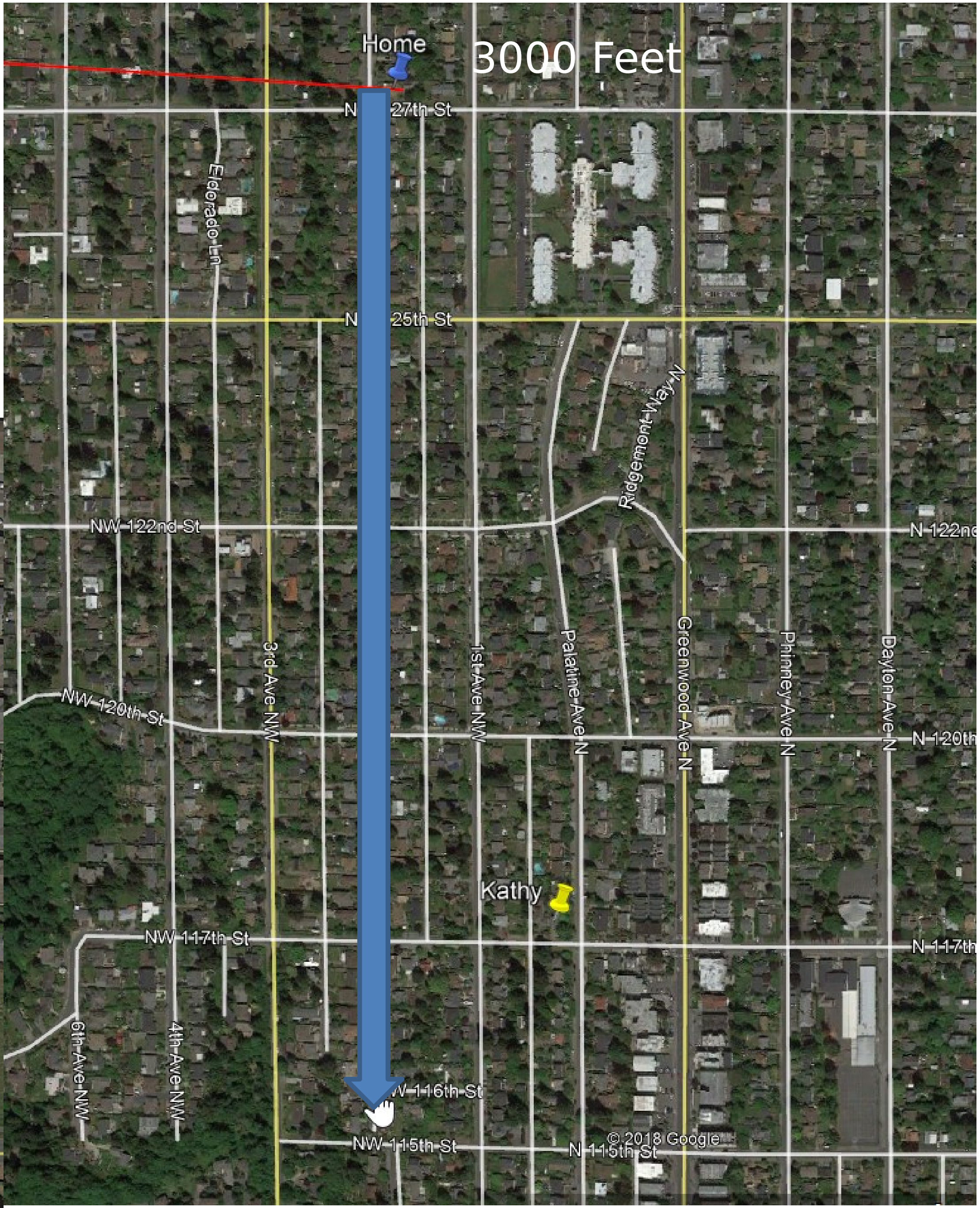
Full reception all the way through, and all the way around, Brockey Hall.

Yellow line is 220’, to north wall of Brockey B.




300 feet
Magnitude
Age
Past hour
Past day
Past week
Older
Home
NW 127th St
1st Ave NW


700 Feet
NW 127th St
1st Ave NW
2nd Ave NW
125th St
© 2018 Google


Home
3000 Feet
N 127th St
Eldorado Ln
N 125th St
Ridgemont Way N
NW 122nd St
N 122nd
NW 120th St
N 120th
3rd Ave NW
1st Ave NW
Palatine Ave N
Greenwood Ave N
Phinney Ave N
Dayton Ave N
Kathy
NW 117th St
N 117th
6th Ave NW
4th Ave NW
NW 116th St
NW 115th St
N 115th St
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Questions ??

Downloads

N7KUW.COM/hop

Copy of this presentation (pptx & pdf)
Programming info & text files for Mikrotik

N7KUW.COM/CommAcad

My other classes

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